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CHIEF OF TECHNICAL DEPARTMENT VACUUM OIL COMPANY

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CASSIER'S MAGAZINE

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# SAFETY IN AMERICAN RAILWAY TRANSPORT

By Charles A. Howard

The question of the reduction of the number of railway casualties in the operation of railroads in the United States has reached a point where it is evident that something must be done to bring this important element in railway operation under definite control. Methods which were fairly satisfactory in the earlier stages of the transport problem have become outgrown, and it is apparent that the prevention of accidents must be brought up to a point comparable with the perfection which has been attained in other departments of operation. Mr. Howard indicates the lines along which such improvement may be made, and his discussion of the subject will repay careful and thoughtful perusal.—THE EDITOR.

CONDITIONS in railroad operation have changed so much during the past decade that the methods which were formerly used and found successful and satisfactory, in many cases to-day, are entirely inadequate. The railroads have fallen behind the industrial development of America both in the increase of their rolling stock and in improvements and additions to their roadway, as well as in the perfection of their organizations. When the average mileage made by freight cars in the United States, including only those in actual service, is only 23 miles per day, which was the case in 1906 and if anything is less to-day, there is something wrong. In some instances, it is simply a lack of cars; in others, insufficient tracks and motive power; in still others, wholly inadequate freight yards and terminal facilities, but the one great cause that is paramount above all others and applies to nearly every case, is the inabilty to mantain a heavy density of traffic on account of poor signal apparatus and antiquated methods of handling trains, causing frequent and costly delays on account of wrecks and other tie-ups incident to this method of operation.

### IMPROVEMENTS IN PRESENT ROADWAY NECESSARY.

In some few cases, an increase in the roadway is sadly in need, but in general it may be said that by suitable improvements in the existing roadway, and additions to motive power, the present mileage of cars can be increased to an enormous extent by a far less outlay of capital than would be necessary to produce the same increased mileage by adding trackage. The reason for this is the fact that generally the roadway represents approximately 80 per cent. of the total cost of the railroad, leaving only 20 per cent. for the equipment. As an illustration of this, from the reports of the New York Railroad Commissioners, the equipment of the Boston and Maine Railroad represents only 16 per cent. of the total cost, the other 84 per

cent. being in the roadway; on the New York Central, 75 per cent. of the total cost is in the roadway; and on the New York, New Haven and Hartford, 79 per cent. It is manifest, therefore, that as the roadway represents approximately four-fifths of the total cost of the system, that it should, in the interests of its stockholders, be operated at its maximum capacity and not allowed to practically remain idle more than one-half of the time. If the roadway were worked as near to its limit as the motive power equipment is worked, there would be far less trouble from car shortage, and the net earnings of the railway systems would be greatly increased.

TABLE I.

| Passengers. | Killed. | Injured. | Total. | Per Cent Killed. | Per Cent Injured. |
|---|---|---|---|---|---|
| Collisions and derailments | 341 | 6,053 | 6,394 | 63.5 | 58. |
| All other causes | 196 | 4,404 | 5,600 | 36.5 | 42. |
| Total passengers | 537 | 10,457 | 10,994 | 100. | 100. |

### CASUALTIES RESULTING FROM ACCIDENTS.

There is another problem which seems to have been worrying a large number of people of late and that is the already large and rapidly increasing number of people who are killed and injured every year in railroad accidents in this country. The total number of casualties from the report of the Interstate Commerce Commission for the year ending July 30, 1905, including passengers and employees only—no trespassers—was 70,934, of which 4,225 were killed and 66,709 were injured. Of this total number, referring to Table I, 537 passengers were killed and 10,457 injured, and of these passengers, 63.5 percent. were killed and 58 per cent. injured as a result of collisions and derailments, most of the latter being caused by trains running into an open switch, generally left in that condition because some employee was too late or misunderstood his orders or else was negligent of his duty or perhaps he had been working 36 hours without any sleep, which is not at all uncommon. All of the collisions with such few exceptions that they may be disregarded are caused by faulty signal systems or frequently no signal systems at all, or else because an engineer ran by a signal set at danger.

It can be seen that, by the prevention of collisions and derailments, three-fifths of the number of casualties to passengers may be prevented, while the other two-fifths are spread among a diversity of causes, as getting on and off trains in motion, which accounts for a large portion of the casualties, and being run down by trains in stations, such accidents being caused in general

TABLE II.

| Class. | Accident. | Killed. | Injured. | Total. | Per Cent Killed. | Per Cent Injured. | Per Cent Total. |
|---|---|---|---|---|---|---|---|
| 1 | Collisions | 95 | 3,744 | 3,839 | 26.6 | 35.6 | 35.2 |
| 2 | Derailments | 51 | 2,309 | 2,360 | 14.2 | 22.0 | 21.7 |
| 3 | Parting of trains | .. | 61 | 61 | .... | .6 | .6 |
| 4 | Locomotives and cars breaking down | .. | 11 | 11 | .... | .1 | .1 |
| 5 | Falling from trains | 53 | 437 | 490 | 14.8 | 4.1 | 4.5 |
| 6 | Jumping on and off trains | 89 | 1,529 | 1,618 | 24.8 | 14.5 | 14.9 |
| 7 | Struck by trains | 54 | 120 | 174 | 15.1 | 1.1 | 1.5 |
| 8 | Other causes | 16 | 2,312 | 2,328 | 4.5 | 22.0 | 21.5 |
| | Total | 358 | 10,523 | 10,881 | 100. | 100. | 100. |

by the carelessness of the passenger and largely beyond the control of the railroad.

To bring this out a little plainer, and also to show that this ratio of people killed in collisions and derailments is not more excessive than usual for this particular year, 1905, Table II. is given, which shows in more detail the manner in which the various passengers were injured or met their death during the year 1906. From this table it will be seen that 26.6 per cent. of the passengers were killed and 35.6 per cent. injured as a result of collisions alone. It will also be noted that classes 5, 6 and 7 are accidents, due primarily to the carelessness of the passenger, and nearly unavoidable by the railroad. If these accidents are considered as inevitable, which is pretty near the case under the present method of handling passengers, it leaves practically all of the remainder of accidents due to either derailments or collisions, of which collisions take care of approximately 60 per cent.

FEW FAILURES OF EQUIPMENT.

To show how far the construction of the cars and locomotives is ahead of the methods of controlling trains, just note the numbers of casualties in class 4 caused by the breaking of locomotives and cars. When it is considered the number of things that could happen—brake rigging drop, an axle break, a tire break, a wheel break, boiler explode, connecting rod break, or a hundred other failures—it is certainly wonderful what a small number of accidents occur. Contrast this with the accidents due to mistakes in train operation, where practically the only two errors that can occur are the operator setting the wrong signal or the engineer running by a danger signal, yet the casualties resulting from collisions are 352 for every one caused by failure of equipment.

MOST EMPLOYEES KILLED IN COLLISIONS.

The following table will show the number of employees killed and injured in the different classes of accidents during the year 1905:

TABLE III.

| Accident. | Killed. | Injured. | Per Cent Killed. | Per Cent Injured. |
|---|---|---|---|---|
| Coupling cars | 230 | 3,543 | 6.0 | 6.4 |
| Falling from trains | 479 | 5,330 | 12.5 | 9.8 |
| Jumping off moving trains | 162 | 4,537 | 3.6 | 8.1 |
| Collisions and derailments | 672 | 5,523 | 17.8 | 10.0 |
| Unclassified | 2,264 | 36,581 | 60.1 | 65.7 |
| Total | 3,807 | 55,514 | 100. | 100. |

Of these collisions shown above, practically all except those in classes 2 and 7 could have been prevented by an automatic block signal, protected by an automatic stop. This would have cut the number of people killed by 70 per cent., the number injured by 65 per cent. and the damage to road and equipment by 71 per cent.

One of the first installations of the automatic train stop was on the express tracks of the New York subway, and no collision of any description has occurred on any portion of the line on which the stop was installed. The densest traffic of any steam railroad in New York State, and probably in the United States, is the Erie, which operates, on the average, over all its lines, Sundays included, 43 trains every 24 hours. On the New York subway, 693 trains pass over every mile of line every 24 hours. Of this system 28 per cent. of the mileage is four track, so that the above figures reduced to the same conditions as the Erie, that is per mile of double track, would mean that 542 trains pass over every mile of double track every 24 hours,

and that day and night, all the year around, each train follows the next preceding one by an interval of 5.3 minutes.

NO SIGNAL ALONE WILL STOP A TRAIN.

The worst accidents which happen are those collisions which are caused by engineers running by signals set at danger. By glancing at Table IV. it will be seen that this type of collisions represents during this quarter 30 per cent. of all collisions in this class, 26.5 per cent. of the total number killed, 30 per cent of the total number injured and 28.4 per cent. of the damage to rolling stock and roadway. A few individual cases of some of the recent accidents of the above nature may not be out of place here.

On October 1, 1907, at Providence, R. I., the Shore Line Express on the New York, New Haven and Hartford Railroad ran into the rear end of the "Knickerbocker Limited," one of the finest excess-fare trains on this railroad. Fortunately very few persons were in the rear car, which was of very heavy construction, and only three persons were injured.

About this same time a train on the Worcester, Nashua and Portland Division of the Boston & Maine R. R. ran by a signal which was obscured by a cloud of smoke. Eight people were injured in this accident.

Very closely following this collision, the engineer of the "Nyack Flyer" on the Erie R. R. had his head struck by a passing telegraph pole, and as this locomotive was one of the type having a Wooten firebox, necessitating the separation of the engineer and fireman, the train ran for a long distance before the fireman noticed what had happened, and it was only by the greatest good fortune that a serious accident was prevented.

On December 27, 1907, a train on the Pennsylvania R. R. crashed into the rear of the Atlantic City Express in Camden, N. J., having run by a danger signal in the fog. Four people were killed and twenty-one injured in this accident.

On December 30, 1907, at Terra Cotta, D. C., the Frederick Express on the Baltimore and Ohio R. R. was struck in the rear by an extra train which had run by a red light at a speed of 60 miles an hour. In this accident 43 people were killed and over a hundred injured.

This just gives an idea of a few of the collisions which have taken place in the Eastern part of the United States during a recent period of about two months, all caused by the fallibility of the human element of the engineer. It is also very interesting to note the frequency with which engineers will take their chances and run by a signal that they cannot see, assuming that it is at clear. The actual number of times which this offence is committed can never be known, as usually the signal does read "clear," and it is only in cases of disaster that this fact is brought out in public. The average locomotive engineer is a man of exceptionally clever judgment and can take a great many chances of this kind before he makes a mistake; but the time always comes when an error is made, as the statistics show, and with due consideration for passengers this condition should not be allowed to exist. No block signal of itself ever stopped a train. Without the co-operation of the engineer it is useless, but if the automatic train stop is used, even if the engineer does disregard the signal, his train will be stopped in spite of him.

AUTOMATIC TRAIN CONTROL IS NOW IN SUCCESSFUL OPERATION.

The point will be brought up that there is no such a thing as an automatic train stop that is practicable under railroad operating conditions of to-day. This is not the case, as there are several railroads using them to-day with the best results, so good that they are extending the system further along their various

lines. Those in the New York subway are electrical in character but operated by mechanical trips. In Europe, on the main line between Vienna and Krems, a mechanical stop has been in successful operation for some time. The great majority of people who have reasons for denouncing the automatic stop use the argument that the mechanical trip is very apt to get frozen and inoperative during the severe winters of American climates. The mechanism thus exposed to the elements is of precisely the same character as that which operates the signals and switches, and this mechanism at present has but few faults to be found with it.

Everybody who has ever had anything to do with locomotive operation knows that the minute electricity is brought on to a steam locomotive, trouble begins and never ends until it is taken off. It is almost impossible to prevent grounds; and then, again, the locomotive engineers, as a class, have little use for electricity. One of the worst objections to its use is the fact that it is almost impossible to design an electrical device which cannot be interfered with or allowed to get out of order by the engineer. Any such arrangement to have any safety at all must work on the open circuit plan; that is, when the circuit is open the train is to be stopped, and when this design is in use, the constant grounds which are bound to occur will stop the trains so frequently that this scheme is impracticable. The mechanical method of train stopping, on the other hand, has proven its merit in actual practice where the weather is severe, and is without any delicate adjustments, needs practically no care; its principles and action are already understood by the present engineers, and it is absolutely beyond the control of the engineer. In the glossary of the Interstate Commerce Commission's report the definition of an "Automatic stop" is as follows: "A *mechanical appliance* to be used as or in connection with a block signal on a railroad to stop a train (or car) by cutting off its motive power or setting its brakes or both." From this definition of a train stop by the Commission, it is evident that, after their careful and extensive research of this subject, they have come to the correct conclusion that mechanical means is the only satisfactory method of accomplishing the desired result.

The railroads, to a large extent, declare the automatic stop as unnecessary and impracticable on general railroad principles, just as they did the automatic coupler and the air brake; but they got over it after a limited use of these apparatus when they found out how much they saved every year, and they will do the same with the automatic stop.

### RAILROADS WILL SAVE MONEY BY AUTOMATIC CONTROL.

The primary objection, and in fact the only objection, the railroad companies have to the automatic stop is the cost of installation of the equipment. Let us consider this matter from the stockholder's point of view as well as that of the traveling public and see plainly how several of the large Eastern railroads, for example, are situated in this matter of ability to stand the cost of installation of an automatic stop.

Column I, Table V, shows the total cost resulting from accidents during the year ending June 30, 1906, including injuries to persons and property, damage to road and equipment, clearing wrecks and other expenses incidental to accidents. In making up Column II, it has been assumed that 15 per cent. of the total cost in Column I can be saved by the installation of a mechanical automatic stop. This figure has been arrived at after a very careful study of the causes and results of the railroad accidents of every description which have happened in the United States during the past five years, and is taken on an extremely conservative basis. The estimate of the cost

TABLE V.

| Railroad. | Column I. Cost of Accidents, 1906. | Column II. Cost of Accidents Which Would be Saved by Automatic Train Stop. | Column III. Cost of Installation of Automatic Train Stop on Whole Railroad. | Column IV. Annual Maintenance. | Column V. Annual Net Saving. | Column VI. Interest Earned on the Investment. | Column VII. Total Surplus on Hand June 30, 1906. | Column VIII. Surplus Earned for Year Ending June 30, 1906, Alone. | Column IX. Number of Years for Annual Surplus Earned to Pay for Automatic Stop. | Column X. Percentage of Total Surplus to Pay for Automatic Stop. |
|---|---|---|---|---|---|---|---|---|---|---|
| Boston & Maine | $1,198,875 | $180,000 | $987,000 | $49,350 | $130,650 | 13.2% | $2,591,590.56 | $217,273.00 | 4.55 | 37.4% |
| New York, New Haven & Hartford | 1,025,155 | 153,000 | 988,500 | 49,425 | 104,375 | 10.5% | 15,509,885.09 | 3,718,285.41 | .26 | 6.3% |
| New York Central & Hudson River | 1,973,008 | 296,000 | 1,711,000 | 85,550 | 210,450 | 11.8% | 17,268,423.83 | 2,953,004.56 | .58 | 9.9% |
| Erie | 756,084 | 113,400 | 1,036,000 | 51,800 | 61,600 | 6.0% | 11,979,461.54 | 533,974.71 | 1.94 | 8.6% |
| Delaware, Lackawanna & Western | 129,685 | 19,400 | 174,000 | 8,700 | 10,700 | 6.2% | Not obtainable. | Not obtainable. | .... | ...... |
| Delaware & Hudson | 285,763 | 42,800 | 330,000 | 16,500 | 26,300 | 8.0% | Not obtainable. | Not obtainable. | .... | ...... |
| Lehigh Valley | 346,619 | 51,900 | 694,000 | 34,700 | 17,100 | 2.5% | 11,380,915.31 | 3,827,561.52 | .18 | 6.1% |

of installation of the automatic stop in Column III is on a very expensive foundation, making due allowance for possible royalties on patented inventions. The maintenance of the apparatus is a very uncertain problem at the present time, but by comparison with other machinery of similar mechanical construction, used under similar conditions of service, experience shows that five per cent. of the first cost per annum is not too little. Column V is obtaned by subtracting Column IV from Column II. Column VI shows the interest on the investment that would be made by the installation of the train stop. Column VII gives the total surplus on June 30, 1906. Column VIII gives the surplus for the year ending July 30, 1906, alone. Column IX shows the number of years that it would be necessary to lay by the annual surplus in order to equip the whole road with the automatic mechanical stop. Column X gives the percentage of the existing surplus which would be required to install the train stop on the whole road. The railroads considered in Table V are very well representative of those of the whole country and have been selected at large without any regard to the status of any particular one.

By referring to Column VI it will be seen that all of the railroads noted, with possibly one exception, would derive a very good rate of interest on the money invested in providing for the safety of passengers and merchandise. It should be noted in considering these figures that no earnings are included which would result from the great amount of increased traffic which it would be possible to handle after the installation of the automatic stop. The above shows plainly that the stockholders of the railroads will derive additional income, due to the elimination of the expense of accidents by an automatic stop, as well as by the increase of traffic. The advertising value of an automatic stop is of great importance to all competing railroads,

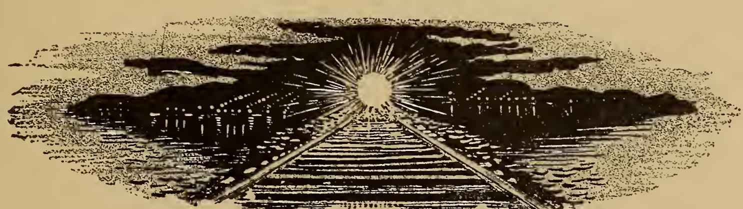
as the greater safety and despatch with which both freight and passenger service can be handled is certain to increase the traffic immensely.

### SURPLUS OF THE RAILROADS AMPLE.

If by reason of the stockholders being able to obtain more profitable investments elsewhere (from 6 to 13 per cent. does not appeal to them), it would certainly be no hardship to nearly all of the railroads to make these improvements out of their surplus. The purpose of a surplus is to provide for just such improvements and not to be used by the directors as means of financing their private enterprises at a low rate of interest or sometimes no interest at all. The average surplus put by every year by all the railroads in the United States per mile of line is $505.00, which would more than equip the total mileage of the country with a means of preventing collisions, with the attendant loss of life and property, and would also increase the amount of traffic which could be handled, thereby decreasing the time of shipment between shipping points and materially reducing the amount of car shortage. Columns IX and X bear out this statement and show that some of the railroads every year put by as a surplus three to four times as much as the cost of equipping the whole road with a perfect train control system.

It is in the interest of the stockholders of all railroads, though possibly not of the directors, that immediate means be taken to accelerate the movement of trains along the line and also to cut out the immense amount of money expended every year because of accidents. If this were done, it would be possible for a great many roads to increase their dividends 2 to 3 percent. without cutting down the present rates of accumulating their surplus.

If the railroads will not make these needed improvements of their own accord, they should be made to do so, the same as they were made to adopt the air brake and the automatic coupler. All shippers of freight should be interested in this problem, as it is the shortest cut to a relief from the present car shortage; and, in fact, there will be no permanent relief until the automatic block system and train stop are installed on all the through trunk lines. The traveling public should also demand these improvements for the safety and rapidity of their journeys, statistics showing that a passenger riding in the United States takes four times the chance of being killed that he does in Great Britain.



# REMARKABLE LOCOMOTIVES OF 1907

By J. F. Gairns

FOR about ten years the developments in the locomotive engineering practice of the world have been both remarkable and numerous, but it is somewhat difficult to estimate the importance of 1907 in this respect, for although there have been a large number of more or less remarkable designs introduced into practice there are comparatively few actually novel or remarkable features to be recorded This is partly due to the fact that previous development has been so rapid and continuous that a stage has been reached when all requirements can be met by a multiplication of the designs already in use (there are many cases where there are more than enough of the remarkable locomotives already in use to meet all special requirements so that in several instances new locomotive building has related only to older and smaller designs), and in other cases development has been merely dimensional or has consisted of the application of features already introduced for certain locomotive types to other types of a particular railway, or the adoption of features by one railway that are already characteristic of the locomotives of another railway or another country.

Consequently one is faced with the difficulty in a review of this character of deciding what is real development in locomotive engineering and what is merely development as compared with the practice already existing on a particular railway or in a particular country. To indicate what is meant a few remarks concerning some of the features of modern locomotive engineering will be in order.

There are now five main classes in which modern locomotive boilers can be placed, (1) the ordinary straight-barrelled boiler with ordinary round-topped firebox, (2) the straight-barreled boiler with Belpaire firebox, (3) the straight-barrelled boiler with wide firebox, (4) the tapered or "wagon-top" boiler with round-topped, Belpaire or wide firebox, and (5) the water-tube boiler. All of these were already in use before 1907, with, of course, many graduations of actual and relative dimensions, though the water-tube boilers were very few in number; and at the present time the situation is, to all intents and purposes, unaltered. The use of extended smoke boxes, fire-box water-tubes, oil-fuel fittings and the use of mechanical stokers are equally devoid of special interest as regards practice, though as regards mechanical stokers there are signs of important progress.

As regards the actual engine—cylinders, motion, valve gear, etc.—there is little of special interest. For instance, before 1907 the increasing favour of the Walschaert valve gear was already a remarkable feature of practice, and while this is still worthy of note, it is not specially characteristic of the past year. The crosshead valve gear used for one new engine of the Midland Railway, of England, had already been used for one engine of the Great Western Railway; the Lentz poppet valves were already in use in Germany; and the Alfree-Hubbell valve gear was

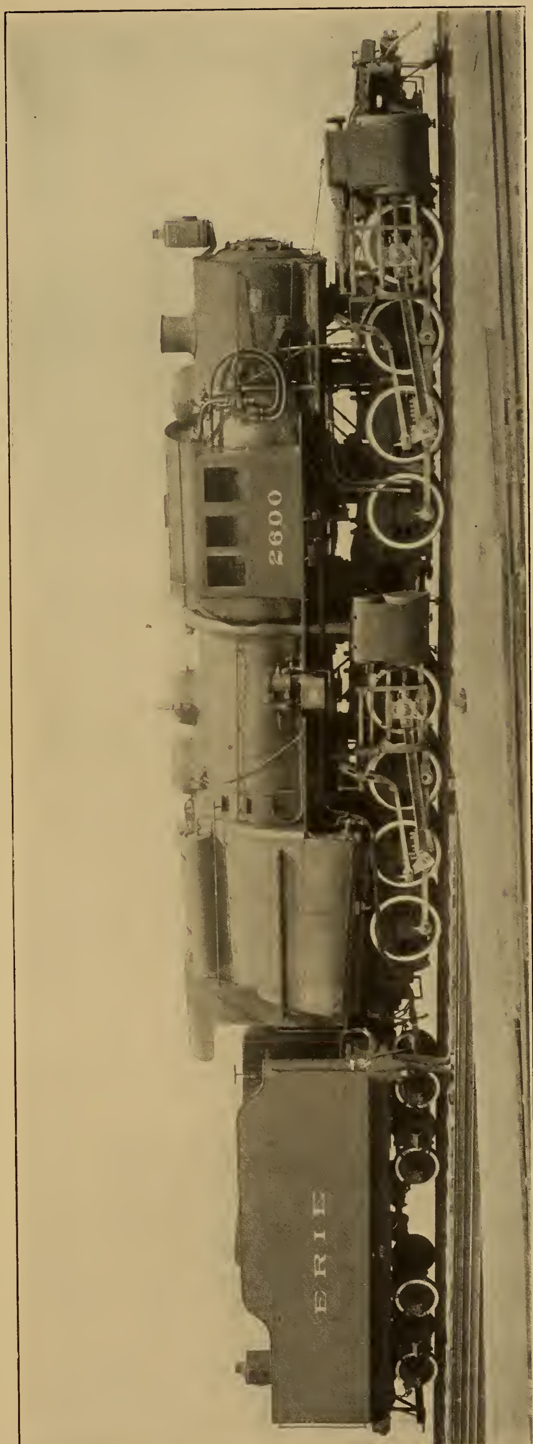


FIG. 1.—MALLET COMPOUND LOCOMOTIVE FOR ERIE R. R. AMERICAN LOCOMOTIVE COMPANY. TOTAL WEIGHT ON DRIVERS, 409,000 POUNDS

already in use in the United States. The use of four high-pressure cylinders is, perhaps, more remarkable of 1907 than of previous years; but it does not owe its inception to the year just completed. The adoption of superheating apparatus is rapidly gaining in favour, and 1907 is somewhat important in this respect, there being one case of a new type of apparatus being introduced and a large number of additional engines fitted; but here again most of the lines of development had already been set before the completion of 1906. The position of compounding is neither better nor worse, though one new system has been introduced during the year; but against this must be set the general tendency against compounding now characteristic of the United States, and in Germany superheating is seriously menacing the development of compounding. In other countries, however, there is little to be said on this score that could not as well be said concerning 1906. As regards wheel arrangements and general types, though there is one case of the introduction of an absolutely new wheel type and another case of the adoption of an old type for express engines that was previously associated with goods or freight engines only, while one of the especial express type previously only found in American practice or for large, narrow-gauge engines (the 4-6-2 "Pacific" type) has made its appearance in France and in England for standard railways, there is comparatively little of special note in this connection. Otherwise all developments relate to the multiplication of existing types, and there are very few cases of their adoption on railways not previously employing them.

There are, of course, many other features of locomotive engineering practice; but the remarks concerning them would be of a similar nature. It will, therefore, be seen that there is comparatively little of special remark in the way of actual innovation to be credited to 1907; and yet it is incontestable that the year has been a really important one, for there have been quite a large number of remarkable locomotives introduced in various parts of the world, though there are cases where the number of remarkable locomotives to be credited to a particular country is comparatively or actually very small. For this reason the present review of the locomotive record of 1907 must take the form of a description of a series of locomotives which are principally remarkable from a dimensional point of view or as compared with the practice of the railway or country to which they relate, while the innovations in locomotive practice are very few. In many cases, too, the bulk of the locomotive building of a particular country consists of the multiplication of existing types and designs, and for that reason it is not proposed to attempt to review national progress, but rather to consider the remarkable locomotives in classes, irrespective of nationality; and as the most convenient method of classification is according to wheel type, that classification will be adopted in a descending scale, according to the number of coupled or driving wheels.

What is probably the most remarkable locomotive of the year requires first consideration, according to this method of procedure, the engine illustrated in Fig. 1 being the present "largest locomotive in the world." Needless to say, this distinction is claimed by America, for no other country offers so few restrictions to over-all dimensions of locomotives nor calls for such powerful engines. This engine is particularly notable as showing what is possible even on the standard gauge of 4 feet 8½ inches, providing heavy rails and solid permanent way are available. The first Mallet articulated, compound locomotive in America was introduced on the Baltimore & Ohio Railroad some three years ago, the engine, which was designed for assisting heavy freight trains

without division, as would otherwise be necessary, over the severe grades of the mountain sections, being the largest locomotive in the world at that date.

The locomotive now under consideration is a further development of the articulated design, and while derived in many respects from the B. & O. design, and being built by the same firm—the American Locomotive Company—it introduced a wheel arrangement that has never before been employed, viz., with two sets of eight-coupled wheels. Three of these engines have been built for the Erie Railroad, and although they are much heavier and more powerful than the Baltimore & Ohio engine, the essential features of the two designs are the same.

Like the B & O. engine, the new locomotives are designed for banking service on the mountain grades. They are operating between Susquehanna and Gulf Summit, where the ruling grade is 1 in 77 and the pull long and difficult. The average load per axle, notwithstanding the size of the engine, is only 22 tons, and is, therefore, less than that of many road engines of the present day. The boiler is the largest locomotive boiler ever built. It is of the radial-stayed type, with conical connection, the inside diameter of the first or smallest ring being 6 feet 10 inches, while the inside diameter of the largest ring is 8 feet. There are 404 boiler tubes, $2\frac{1}{4}$ inches outside diameter and 21 feet long. The firebox is of the Wootten wide type, 10 feet long and 9 feet 6 inches wide, and has a grate area of 100 square feet. The boiler is provided with a midway combustion chamber 4 feet long, which is radially stayed to the shell of the boiler. The engines are compounded on the Mellin system, so far as the intercepting valve, which is located in the upper part of the left cylinder casting, is concerned.

The flexible connections are the same as those used in the B. & O. design, which have proved so satis-

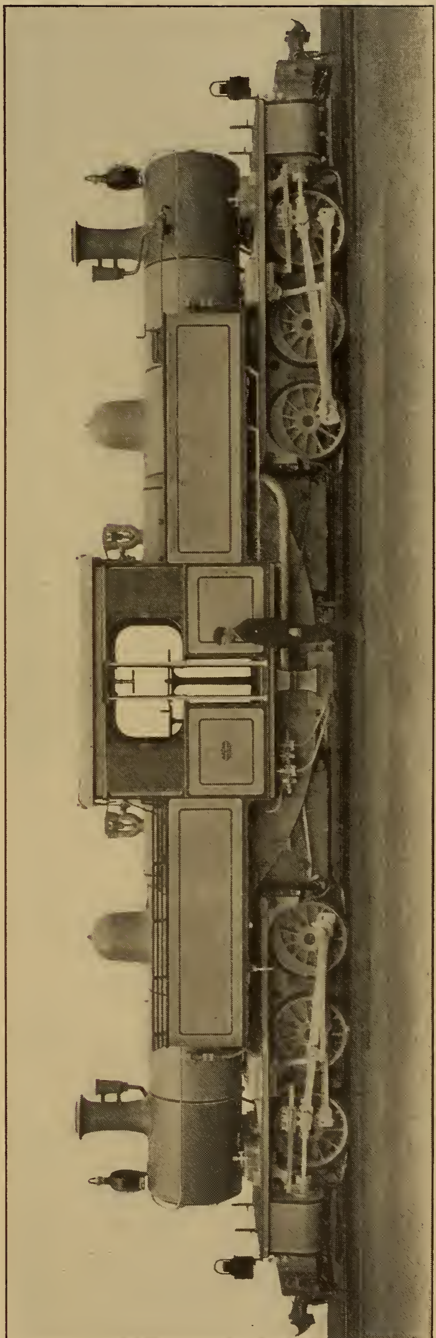


FIG. 2.—FAIRLIE LOCOMOTIVE FOR THE BURMA RAILWAYS. VULCAN FOUNDRY CO., LTD., NEWTON-LE-WILLOWS ENGLAND

factory, no trouble from leaky joints having been experienced. Steam from the low-pressure cylinders, which are located considerably ahead of the front end of the boiler, exhausts back through a flexible pipe connection to the exhaust pipe in the smokebox. The high-pressure cylinders are equipped with piston valves, and the low-pressure cylinders with Richardson balanced slide valves. The valve gear is of the Walschaert type. By an ingenious arrangement of the reversing gear the weights of the valve motions of the front and rear engines counterbalance each other. As the high-pressure valves are designed for internal admission and the low-pressure external admission, it was possible with this arrangement of reversing gear to obtain a most satisfactory valve motion with both eccentric cranks leading the crank pin, the rear engines taking the forward motion from the top of the link and the front engines from the bottom of the link. Pneumatic reversing gear with positive automatic locking in any desired positions is employed. The boiler is supported by the forward engines through a self-adjusting sliding bearing located between the third and fourth driving wheels. Movement in a vertical direction is prevented by a safety connection between the boiler bearing casting and the cross-tie, which prevents the frames from dropping away from the boiler in case of any derailment. There is also a similar safety connection provided at the front end of the boiler.

In consequence of the use of the wide Wootten firebox, and in view of the huge size of the engine, the driver is located in a cab mounted over the boiler, the fireman alone occupying the usual footplate. These engines have been constructed at the Schenectady Works of the American Locomotive Co.

During 1906 a series of 2-6-6-2 articulated compound engines were constructed by the Baldwin Works for the Great Northern Railway (U. S. A.). These were designed for banking work, but since that date a similar design has been introduced for ordinary road service. They correspond in many respects with the banking engines, but the boiler is somewhat smaller and the total weight appreciably less. Articulated locomotives of this type, supplied by the Baldwin Works, and also a series of 0-6-6-0 engines corresponding generally to the original engine of the Baltimore and Ohio Railroad and constructed by the American Locomotive Company, have been introduced on several other railways in the United States and also for use in the Central Railway of Brazil, so that there is now a

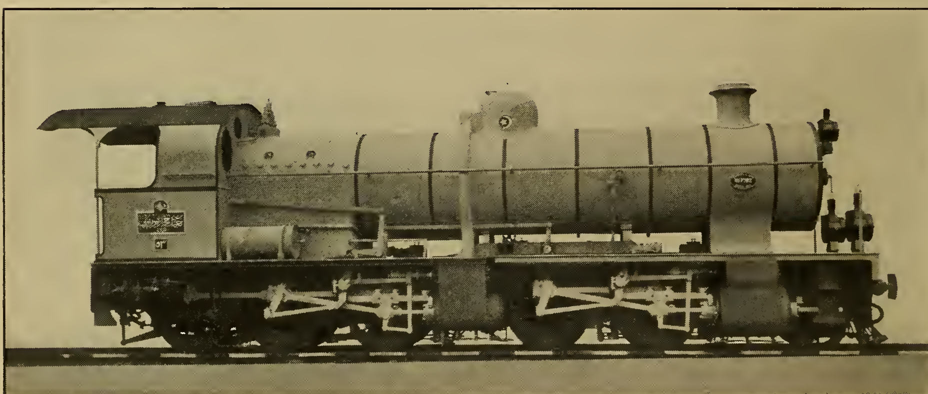


FIG. 3.—ARTICULATED LOCOMOTIVE FOR THE HEDJAZ RAILWAY, ARABIA. HENSCHEL & SOHN, CASSEL, GERMANY.

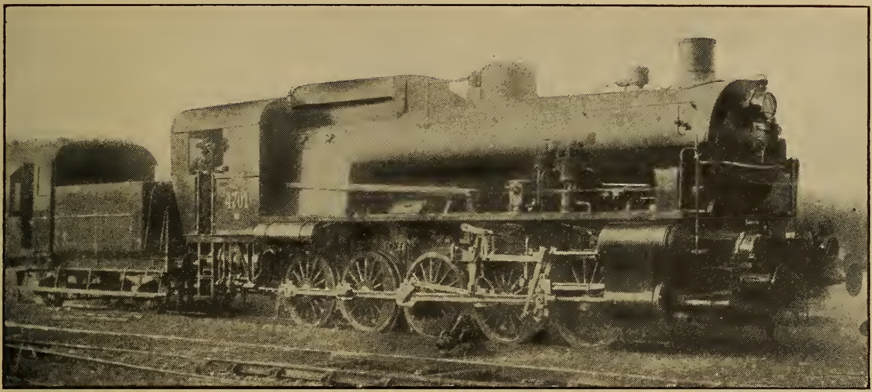


FIG. 4.—BANKING ENGINE FOR THE ITALIAN STATE RAILWAYS. ERNESTO BREDO, MILAN

considerable number of articulated compound locomotives constructed by American locomotive-building firms.

Fig. 2 illustrates an engine having twelve driving wheels arranged in two articulated sets, but in this case the engine is not compound and the Fairlie type is employed, there being two boilers, which in this case are quite separate, though mounted on the same frame. This engine is one of a series supplied by the Vulcan Foundry Co., Ltd., of Newton-le-Willows, England, for the Burma railways (3 feet 6 inches gauge). The design, though a remarkable one, is a development of that introduced in 1901, when the first engines of this class were constructed by the same firm. By the employment of this design a powerful machine is obtained that can be controlled by one driver with, perhaps, two native firemen, although each section is equivalent to an engine of small dimensions and that is light on the permanent way. These engines are used for the mountain sections, and in places have to negotiate grades as steep as 1 in 27 with fair loads. Two of the four bunkers are used for fuel and two for water, but as the water stations are in places a long distance apart a tender is generally attached, from which the engine tanks are refilled as required.

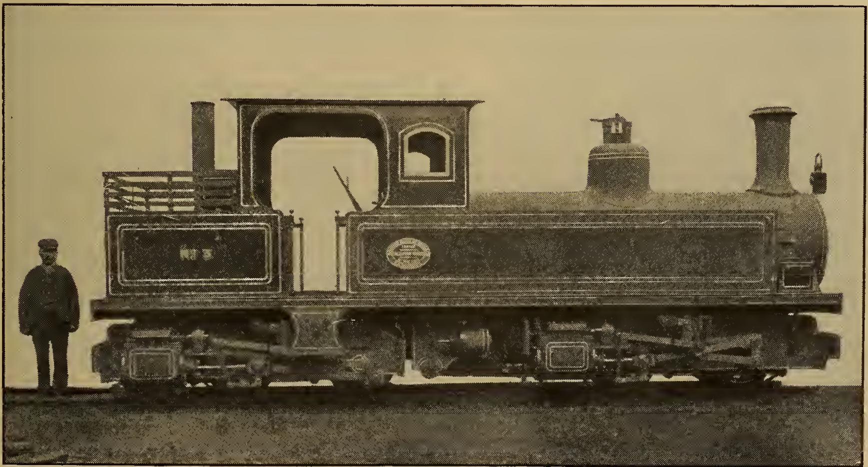


FIG. 5.—ARTICULATED ENGINE FOR GREECE. ANDREW BARCLAY SONS & CO., LTD., KILMARNOCK, SCOTLAND

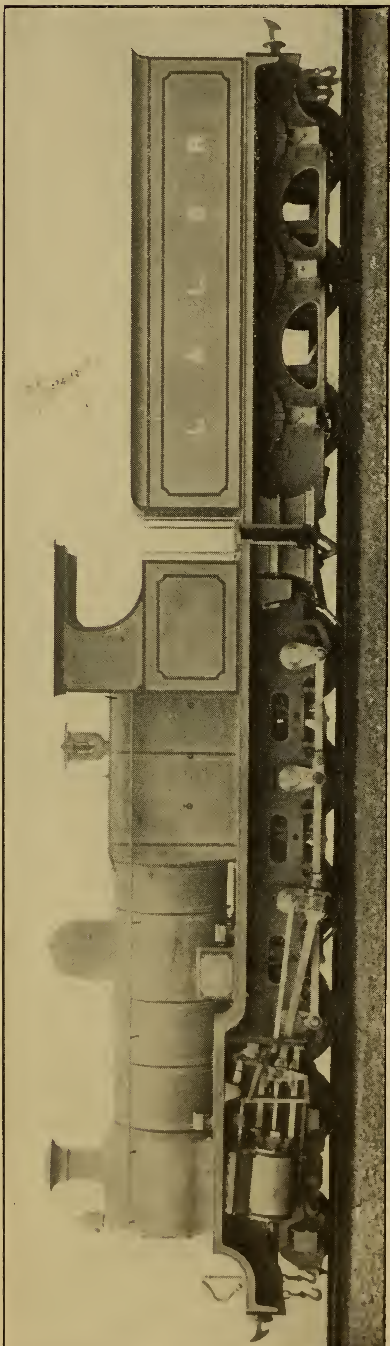


FIG. 6.—NARROW-GAUGE GOODS ENGINE, LONDONDERRY & LOUGH SWILLY RAILWAY, IRELAND. HADSWELL, CLARKE & CO., LEEDS

Although the Mallet articulated type has previously been particularly a feature of European practice it is somewhat interesting that most of the remarkable engines of this class should appear in American practice; but in Fig. 3 a large engine (for the 3 feet 6 inches gauge) is shown, constructed by Messrs. Henschell & Sohn, of Cassel, Germany, for the new Hedjaz Railway (Arabia) of the Ottoman State Railways. This design is peculiar because the leading bogie has four coupled wheels and a pair of leading wheels, so that the wheel arrangement is 2-4-6-0. When considered in reference to the gauge these engines must be estimated as remarkable productions, especially as the railway for which they are employed is one constructed for opening up new country. They are designed for dealing with loads up to about 250 to 300 tons over gradients of about $1\frac{1}{2}$ per cent.

So far the engines described or referred to have the driving wheels, whether totalling 16, 12 or 10, arranged in two sets, but reference is now necessary to locomotives having ten coupled wheels, and corresponding to general practice as regards engine design. Ten coupled engines, with or without additional carrying wheels, were previously in use in Austria, Alsace-Lorraine, Prussia, South America and in the United States, but the past year has witnessed the introduction of several interesting designs of this class. In the United States a series of 2-10-2 engines has been introduced on the Pittsburg, Shawmut & Northern Railway, but one of these was illustrated and described in the February, 1908, issue of this magazine, as the design was the first to incorporate the Baldwin or Vauclain superheater whose introduction must be reckoned as one of the noteworthy features of the record of 1907.

Fig. 4 illustrates a ten-coupled tank engine, with separate four-wheeled tender attached, as used for banking service on the mountain

sections (in places the grade is 1 in 40) of the Italian State Railways. On these sections some remarkable 4-8-0 two-cylinder compound engines are employed for working trains, both passengers and goods, and the latter have hitherto been usually banked by similar engines, though the new ten-coupled engines are designed to supersede them for this latter service. The new engines are, however, four-cylinder compounds, corresponding with the various four-cylinder compound express engines (a new class of these is referred to later) used in Italy, wherein there are two high-pressure cylinders on one side of the longitudinal centre line, one cylinder outside the frames and the other inside, the respective cranks being 180 degrees apart, and two low-pressure cylinders similarly arranged on the other side of the centre line. The steam distribution of each pair of cylinders is controlled by one large piston valve (the ports are crossed so that the cylinder castings are somewhat complicated) above the outside cylinders, as shown. The boilers are also somewhat remarkable, as they are provided with large, wide fireboxes. The engines under notice have been constructed by the well-known firm of Ernesto Bredo, of Milan.

Before dealing with remarkable eight-coupled engines, an eight-driver articulated engine (not compound) will be described, though the engine is a small one. It is one supplied by Messrs. Andrew Barclay Sons & Co., Ltd., of Kilmarnock, Scotland, for an industrial railway in Greece and is illustrated in Fig. 5. It differs from the articulated engines already described in that there are two pivotally mounted sets of coupled wheels operated by two pairs of high-pressure cylinders supplied from a single boiler. The engine, therefore, belongs strictly to the Meyer duplex type, now little used, though at one time it bid fair to be in considerable favour and would probably have been introduced still more largely had it

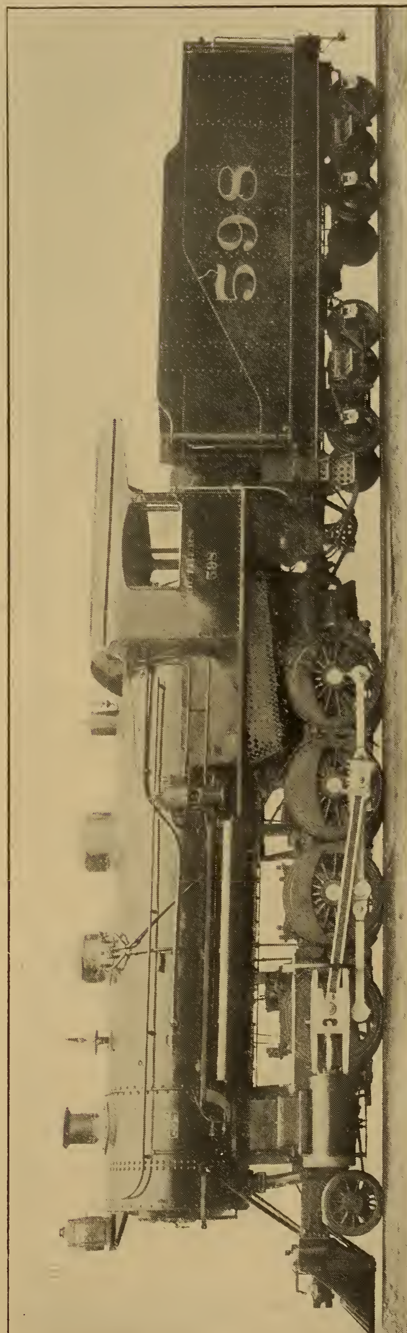


FIG. 7—CONSOLIDATION LOCOMOTIVE FOR THE SOUTHERN RAILWAY, U. S. A., AMERICAN LOCOMOTIVE COMPANY

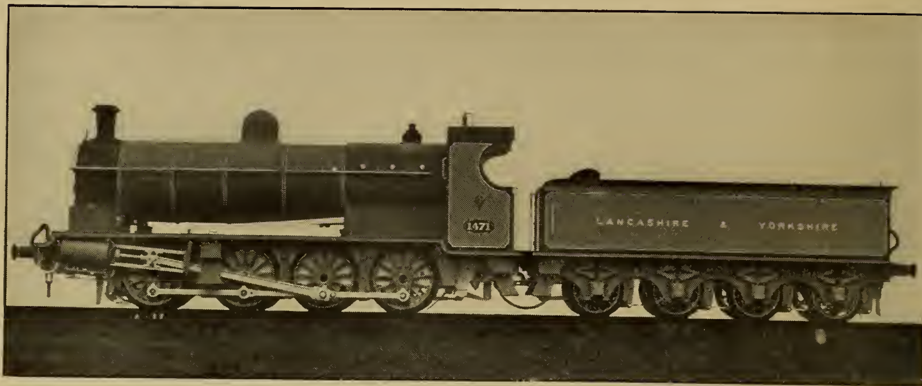



FIG. 8.—COMPOUND MINERAL LOCOMOTIVE, LANCASHIRE & YORKSHIRE RAILWAY

not been for the Mallet compound articulated design, which has superseded it in most cases.

The conditions required considerable hauling power on very light rails with numerous sharp curves on steep grades; and it was considered that the requirements could be best met by the adoption of a duplex design.

The gauge is very narrow, only 2 feet 5½ inches, so that the designers were considerable hampered; but this provided a further reason for the adoption of this design, as the tractive effort could be divided over a multiplicity of driving axles spaced over an extended wheelbase. As a result a comparatively large and powerful machine is provided, having eight wheels available for tractive power and well distributed, so as to distribute the load, all of which is utilized for adhesion, while ample flexibility in service is provided.

The boiler, water tanks and coal bunkers are supported on a main frame, running the full length of the engine. This frame is carried by two four-wheeled bogies, each provided with a separate set of engines with Walschaert valve gear. The steam supply is furnished for both sets of engines by one boiler, and ball and socket joints on the steam pipes permit the bogies to assume any

FIG. 9.—GOODS LOCOMOTIVE FOR THE OTTOMAN RAILWAY. STEPHENSON & CO., DARLINGTON, ENGLAND


FIG. 10.—GOODS LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAYS. HANOVER MACHINE WORKS

position within their range of movement. The exhaust from the front engine takes place in the usual way; that of the rear engine is provided for by a special chimney passing through the coal bunkers.

Dealing now with eight-coupled engines, Fig. 6 illustrates a 4-8-0 engine, introduced during 1907 for an Irish narrow-gauge railway (the Londonderry and Lough Swilly Railway, 3 feet 0 inch gauge).

On this line the locomotives are mostly tank engines of the six-coupled bogie types, having the wheel arrangements known as 4-6-0 and 4-6-2, that is, with a leading bogie, six-coupled wheels, and, in


FIG. 11.—TANK LOCOMOTIVE FOR THE ROSARIO-PUERTO-BELGRANO RAILWAY, ARGENTINA. A. BORSIG, TEGEL-BEI-BERLIN

some classes, a pair of trailing wheels fitted in radial axle-boxes. These engines are somewhat remarkable, considering the gauge and the traffic conducted; but recent developments have rendered the introduction of even larger locomotives necessary, therefore two eight-coupled tender locomotives, designed by Mr James Connor, the late locomotive superintendent of the railway, were built by Messrs. Hadswell, Clarke & Co., Ltd., of the Railway Foundry, Leeds, one of these being illustrated.

These locomotives are intended for working-goods trains from end to end of the line, each of them doing a double journey of seventy-five miles daily. As the water stations are considerable distances apart the adoption of separate tenders was decided upon, especially as the increased power required would have necessitated unduly large tank engines to meet the same requirements. In consequence of the narrow gauge the frames are outside the wheels, so that the firebox dimensions are comparatively unrestricted, and the coupling rods are connected to outside cranks. The outside cylinders operate on to the second coupled axle, and the Walschaert valve motion, controlling slide valves above the cylinders, is employed. The leading coupled wheels are not provided with flanges, so that the rigid wheel base is very short, and curves of 600 feet radius and even less can be safely negotiated. In places the gradients are very severe, including one of four miles at about 1 in 50. A large firebox of the Belpaire type is employed, and in every respect the dimensions are considerable, having regard to the narrowness of the gauge, and the fact that huge locomotives such as are employed on the very substantial narrow-gauge (3 feet 6 inches) lines used in South Africa, are not required in Ireland.

The automatic vacuum brake apparatus is fitted, in addition to steam and hand-brakes for use on the engine and tender only. Central coupling buffers are fitted, as usual, on these narrow-gauge lines.

The 2-8-0 ("Consolidation") type is by far the most common for heavy goods' traffic and therefore several of these engines must necessarily be included, and others mentioned.

Fig. 7 illustrates a large engine of this type constructed by the American Locomotive Company for the Southern Railway (U. S. A.). It is not compound, but the cylinders are large (22 inches by 30 inches), though not so large as sometimes employed in American practice. The boiler is provided with a wide firebox.

Very similar designs have been constructed for various railways by this firm and by the Baldwin Works, including a very large engine exhibited by the Baldwin Works at the Jamestown Exhibition with cylinders, 28 inches by 32 inches. A large engine of this type has been built by the Baldwin Works for the Central Railway of Brazil. This engine is also fitted with the Vauclain superheater.

Large 2-8-0 engines have also been constructed by various European firms, but most of these correspond with earlier practice or are developments thereof.

Fig. 8 illustrates a large eight-coupled engine, designed by Mr. George Hughes, for the Lancashire and Yorkshire Railway of England. Some three years ago this gentleman experimentally adapted one of the standard eight-coupled mineral locomotives as a four-cylinder compound engine, additional outside high-pressure cylinders being placed outside the frames, and the original inside cylinders (bored out) being used for the low-pressure steam. In this engine all four cylinders operated on to the same axle. After exhaustive tests with this engine it was decided to build ten engines as compounds, according to Mr. Hughes' arrangement, one of these is illustrated. A few slight alterations were made so that these engines are not quite

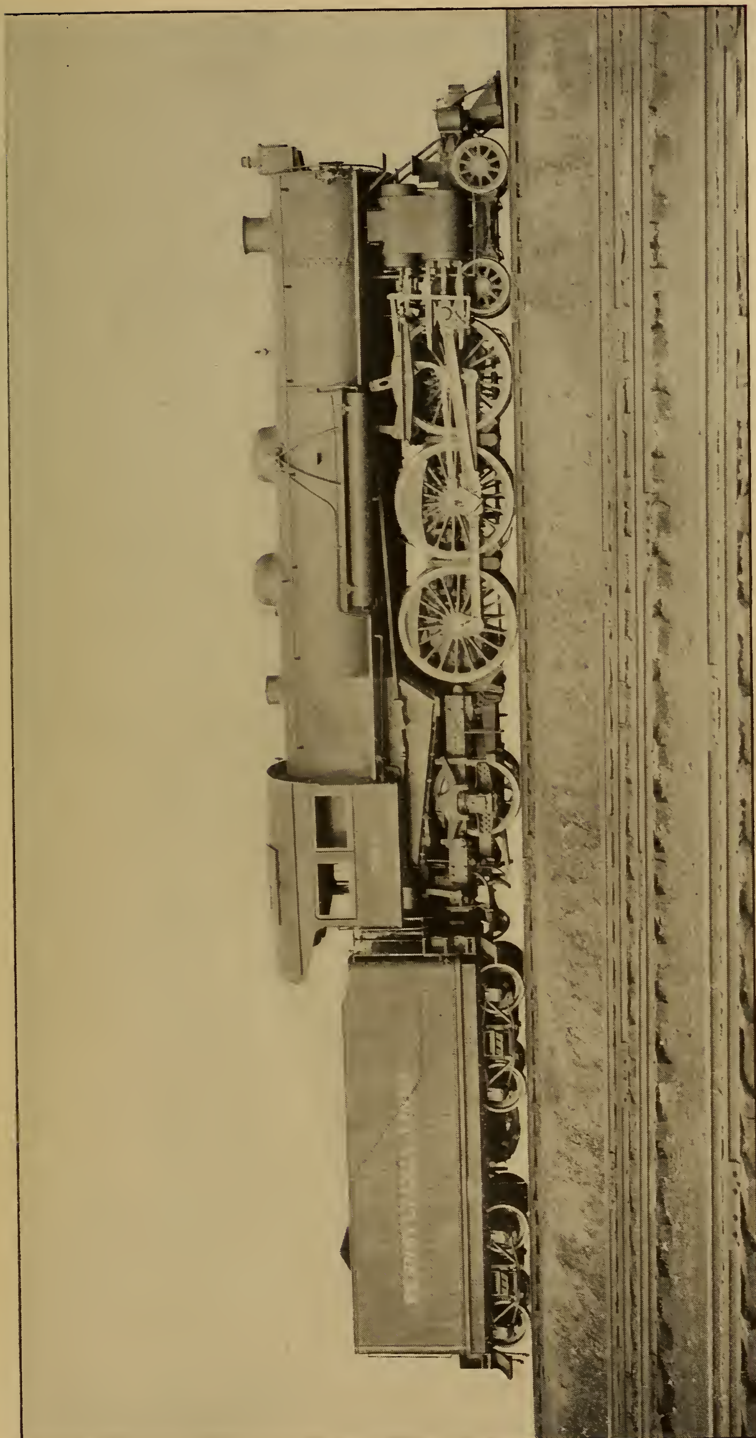


FIG. 12.—EXPRESS LOCOMOTIVE FOR THE PENNSYLVANIA RAILROAD. BUILT BY THE AMERICAN LOCOMOTIVE COMPANY

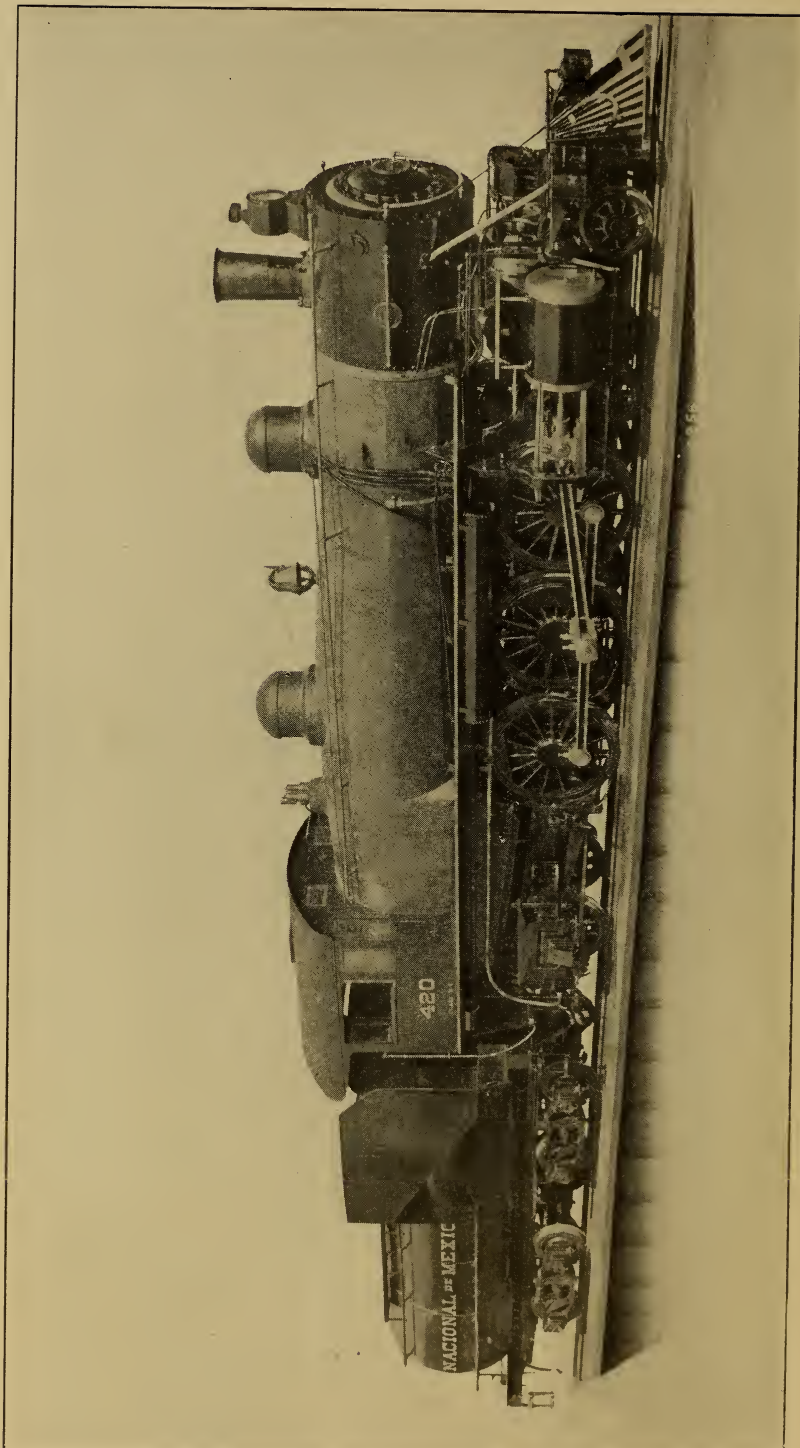



FIG. 13.—VAUCLAIN BALANCED COMPOUND LOCOMOTIVE FOR THE NATIONAL RAILWAY OF MEXICO. BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

FIG. 14.—EXPRESS LOCOMOTIVE FOR THE PARIS-ORLEANS RAILWAY. BUILT BY THE SOCIETE ALSACIENNE

identical with the trial engine, which is, however, still at work, but the principal change is the adaptation of the outside cylinders to drive the third axle, the inside cylinders operating on to the second axle. The design thus corresponds to what is usually termed "divided and balanced," the power being transmitted through two pairs of wheels. The valves, which are of the piston type for the high pressure and Richardson's balanced for the low pressure, are so constructed that steam from the boiler is admitted to the high-pressure cylinders through the central part of the high-pressure valves, and after doing duty in the H. P. cylinders exhausts past the ends of the valves through a tubular receiver into the low-pressure steam chest, where it is admitted to the low-pressure cylinders from the ends of the valves, and finally exhausts through the central part into the atmosphere.

The Joy valve motion is used, one motion driving two valves, namely, one high and one low pressure, through the medium of a two-armed rocking-shaft. For starting the engine, or in case of emergency should the engine tend to stall on a steep bank, an arrangement is employed

FIG. 15.—NARROW-GAUGE LOCOMOTIVE FOR THE FEDERATED MALAY STRAITS RAILWAYS. KITSON & CO., LTD., LEEDS

whereby steam direct from the boiler is admitted automatically to the low-pressure steam chest, through a starting valve so arranged that when the driver places the reversing lever in either full forward or backward gear, boiler steam is allowed to pass into the low-pressure steam chest, thus placing the high-pressure valves in equilibrium. No power at this time is given out by the high-pressure pistons—they simply float in boiler steam—but the low-pressure cylinders are of large diameter (22 inches), so that ample power under these conditions is always available for starting, or for negotiating loads on banks. As soon as the driver links up his reversing gear, the engine automatically changes to compound working. From an extensive number of experiments made with the original compound engine and a single expansion engine of the same type, it is stated that the compound showed a saving of 25 per cent. in fuel, and a corresponding saving in water. This engine is further interesting as being the one-thousandth engine built at the Horwich Works of the L. & Y. Railway.

Fig. 9 illustrates a remarkable eight-coupled engine, constructed by Messrs. Robert Stephenson & Co., Ltd., of Darlington, England, for the Ottoman Railways of Asia Minor. This engine is interesting because no leading wheels are employed, whereas nearly all new eight-coupled engines for various parts of the world are fitted with a leading truck.

On the Prussian State Railways large eight-coupled engines are employed for the heavy goods traffic, and one of these locomotives of large dimensions is shown in Fig. 10, the builders in this case being the Hanover Machine Works. The engine shown is fitted with the Schmidt superheater, hence the very large smokebox, and with the Schmidt piston valves and stuffing boxes. Two of the engines have been experimentally fitted with the Lentz poppet valves (described in CASSIER'S MAGAZINE, July, 1907) for trial against other engines of the same design having piston valves.

Fig. 11 illustrates a remarkable and powerful tank engine, constructed by the well-known firm of A. Borsig, of Tegel-bei-Berlin, for the Rosario-Puerto-Belgrano Railway (5 feet 6 inches gauge) in the Argentine Republic. This is a good example of modern German practice for countries where the neatness and simplicity of design usually associated with British practice are desired. A very similar design has, however, been introduced for the Prince Henry Railway, Luxembourg, where the gauge is the ordinary standard.

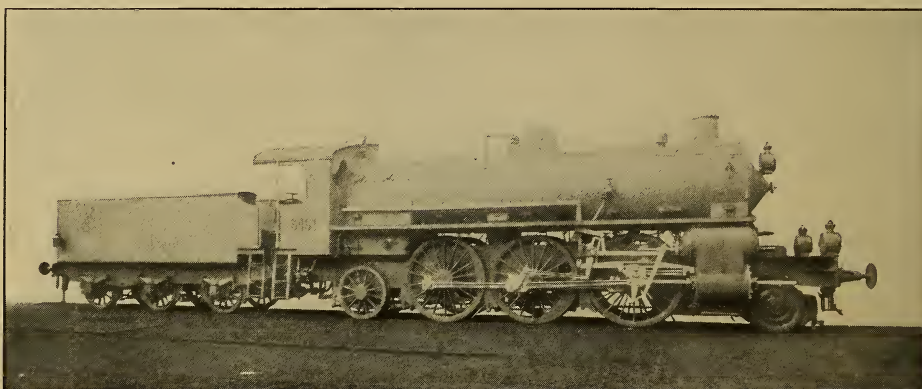


FIG. 16.—EXPRESS LOCOMOTIVE, ITALIAN STATE RAILWAYS. ERNESTO BREDO, MILAN

Reference must now be made to the various six coupled types, and the 4-6-2 or "Pacific" type first requires notice.

Fig. 12 illustrates what is claimed to be the largest passenger engine in the world. It has been constructed by the American Locomotive Company for the Pennsylvania Railroad. It has been designed for hauling the heaviest express trains on the Pennsylvania Railroad main line, so as to enable the trains, which sometimes load up to nearly 500 tons, to be taken by one engine at all times, whereas it has frequently been necessary to divide the trains or use two engines.

The design is developed from the Atlantic (4-4-2) and 4-6-0 express locomotives in use, and it is in no respects an experimental one, consisting principally in dimensional development of previous practice, and it is subject to the previous limit of weight per axle of 27 tons. This is, of course, a weight that is only possible on lines with heavy rails, but with flat-bottomed 110-pound steel rails and high-class permanent way this is a reasonable limit weight. The design is practically derived from the 4-4-2 engines by adding another pair of coupled wheels in front of the firebox, though the boiler is necessarily enlarged and lengthened.

The boiler has a diameter of 6 feet $7\frac{3}{4}$ inches at the first ring, and is of the straight type instead of the conical type that is used by many other American railways.

Fig. 13 illustrates a locomotive of similar type construction by the Baldwin Works for the National Railroad of Mexico, and this is of interest as being one of the few compound locomotives constructed lately in the United States, being a balanced compound engine according to the Vauclain system.

With reference to the type under notice, the year 1907 is remarkable for the fact that it has witnessed the first introduction of this type into

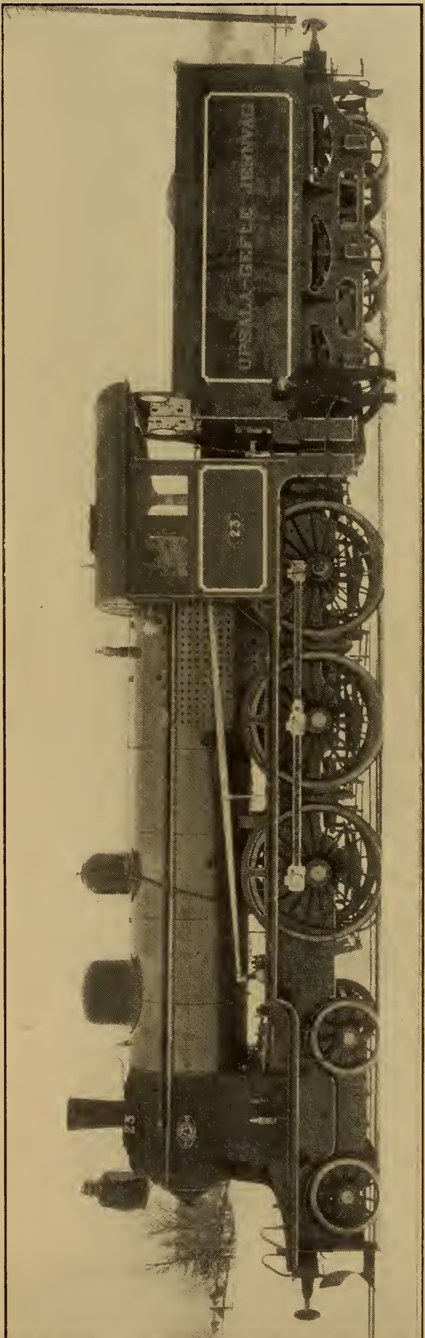



FIG. 17.—EXPRESS LOCOMOTIVE FOR THE UPSULA-GEFLE RAILWAY, SWEDEN. FALUN VAGN & MASKINFABRIKS AKTIEBOLAGET, FALUN SWEDEN

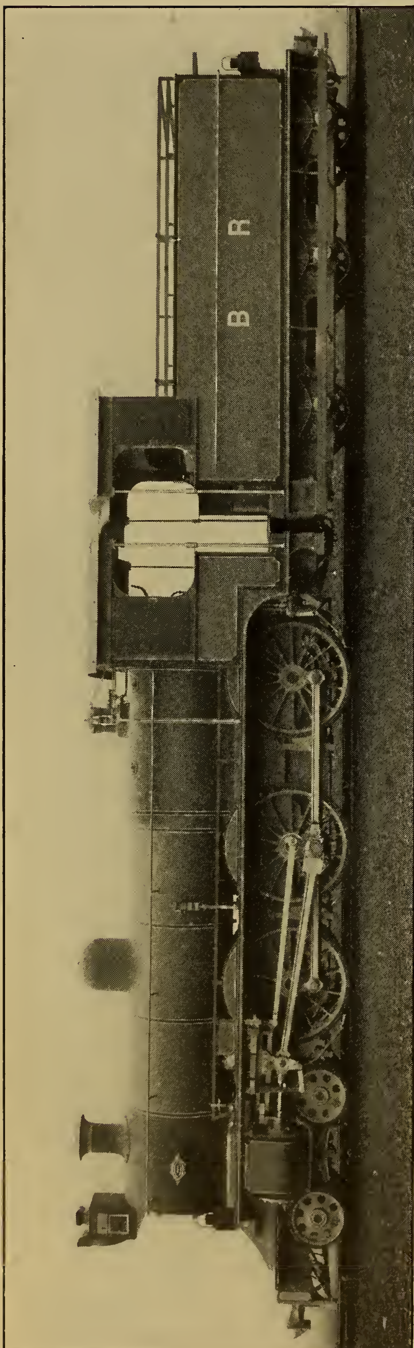


FIG. 18.—PASSENGER LOCOMOTIVE FOR THE BURMA RAILWAYS. R. STEPHENSON & CO., LTD., GREAT WESTERN RAILWAY, ENGLAND

European practice for standard gauge lines, first in France and then in England, though it will shortly be introduced in Germany also.

Fig. 14 illustrates the first French engine of the type for the Paris-Orleans Railway.

It has been found that for certain duties the four-coupled engines (4-4-2) are hardly sufficiently powerful, while the six-coupled engines, with their comparatively small wheels, are hardly suitable for the very fast runs, though they are often used for such work, and therefore a medium-coupled wheel diameter of approximately 6 feet has been adopted, as compared with 6 feet 8 inches (4-4-2 class). The main features of design, such as the large Belpaire firebox, equalizing levers between the coupled wheel axle-boxes, the arrangement of cylinders and mechanism (de Glehn compound system) and the details of construction and fittings correspond with the general practice of this line. Piston valves are used for the outside high-pressure cylinders, and ordinary slide valves for the inside cylinders; steam-reversing gear is used, and the "servo-motor" for operating the change valves for controlling compound or non-compound working is also operated by steam; steam-sanding apparatus is provided in front of the leading and driving pairs of coupled wheels, there being sand-boxes over the leading coupled-wheel splashers, as well as on top of the boiler; the steam pipes leading from the steam dome to the cylinders are led through the boiler and smokebox instead of being placed outside the boiler, as previously usual.

Ten of these engines are on order, and some of them are already in service. Locomotives of corresponding design are also under construction for the French "Midi" Railway and the Alsace-Lorraine Railways.

At the end of 1907 the first English express engine to have the 4-6-2

wheel arrangement was completed, though it was not until the commencement of the present year that the engine was placed in service, so that it is not included in the present review. It belongs to the Great Western Railway and is developed from the 4-6-0 engines already in use, but is noteworthy because of the fact that four high-pressure cylinders are used operating in pairs separate coupled axes, and because of the large boiler dimensions and the use of the Churchward superheater, a constructional variation of the Schmidt smoketube apparatus.

The type is not, however, new to British locomotive building, for it has been used for some time for British-built locomotive of large size for colonial narrow-gauge railways (3 feet 6 inches gauge), and Fig. 15 illustrates an engine built by Messrs. Kitson & Co., Ltd., of Leeds, for the Federated Malay Straits Railways.

As the gauge is only 1 metre they are very large and powerful locomotives, and many features of the design represent careful work to avoid the limitations usually consequent upon the narrowness of the gauge.

The 2-6-2 or "Prairie" type has never been in very extended vogue, for after a short period of considerable favour in the United States it was quickly superseded by the 4-6-2 type, though a considerable number of 2-6-2 engines are in use, some of them of large size and remarkable design. As regards European practice, however, it has only been used on the Austrian State Railways prior to 1907, and one of the events of the past year is its introduction upon the Italian Railways for heavy express traffic.

These engines (Fig. 16) are four-cylinder compounds of the rather peculiar system already referred to. The engine illustrated, which is the first of the new type, is somewhat remarkable in many ways. The boiler is very large and is provided with a large round-topped firebox

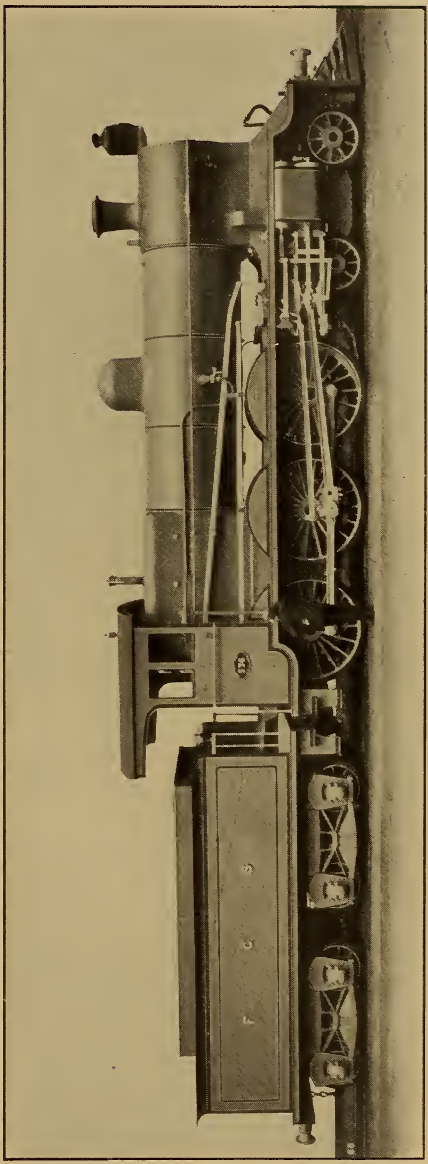


FIG. 19.—FOUR-CYLINDER COMPOUND ENGINE FOR THE BUENOS AIRES GREAT SOUTHERN RAILWAY. VULCAN FOUNDRY, LTD.

with sloping front, and widening towards the bottom to provide large grate area. This wide firebox was one of the reasons for the adoption of a wheel arrangement wherein all the coupled wheels are in advance of the firebox. The illustration shows the outside low-pressure cylinder, and above it the casing of the large piston-valve controlling the two low-pres-

FIG. 20.—SIX-COUPLED FOUR-CYLINDER EXPRESS LOCOMOTIVE

sure cylinders. The inside cylinders are inclined downwards and are at a higher level than the outside cylinders, so that the piston and connecting rods will clear the leading coupled axle, and this fact somewhat complicates the cylinder castings. The large smokebox is provided with a spark arrester, and is supported by the half-saddles formed by the respective cylinder castings. The leading pony truck is pivoted below the cylinders, and a somewhat interesting feature is the use of solid leading wheels. Equalizing levers are employed between the second and third coupled axles, but no other axles are equalized. The driving axle is of the Z-type, as usual in Italian practice.

Reference must now be made to several six-coupled engines of the 4-6-0 type, but as this type is now so usual in the United States that there are comparatively few novelties, though some 4-6-0 engines, constructed by the Baldwin Works for the Central Railway of Brazil, may be mentioned, these being especially interesting because they are balanced four-cylinder compound engines, and are fitted with the Vauclain superheater. There are, however, a number of interesting engines of this class in European and Colonial practice, some of which will be described.

Fig. 17 illustrates an interesting Swedish engine of this type, just introduced, for hauling the express and other passenger trains on the Upsala-Gefles Railway, and they are designed to haul a normal load of seven bogie-coaches, weighing about 240 tons at a speed of about thirty-five miles an hour over grades of 1 in 100, and for maximum speeds of sixty miles an hour. They have been constructed by the Falun Vagn and Maskinfabriks Aktiebolaget of Falun, Sweden. One of the features which differentiate Swedish locomotive practice from that of other continental countries is the fact that many of the modern locomotives are provided with inside cylinders, and the present design is peculiar, because the leading coupled axle of a six-coupled engine is driven by inside cylinders, this practice being largely confined to British and American locomotive design.

The engine is a two-cylinder compound, according to the Mellin system, which is frequently used in Sweden, although the apparatus is of American origin. The Allan eccentric valve gear is employed, and actuates Trick slide valves through a rocking shaft. The boiler is of large size and is adapted for the high-steam pressure of 227 pounds per square inch. An extended smoke-

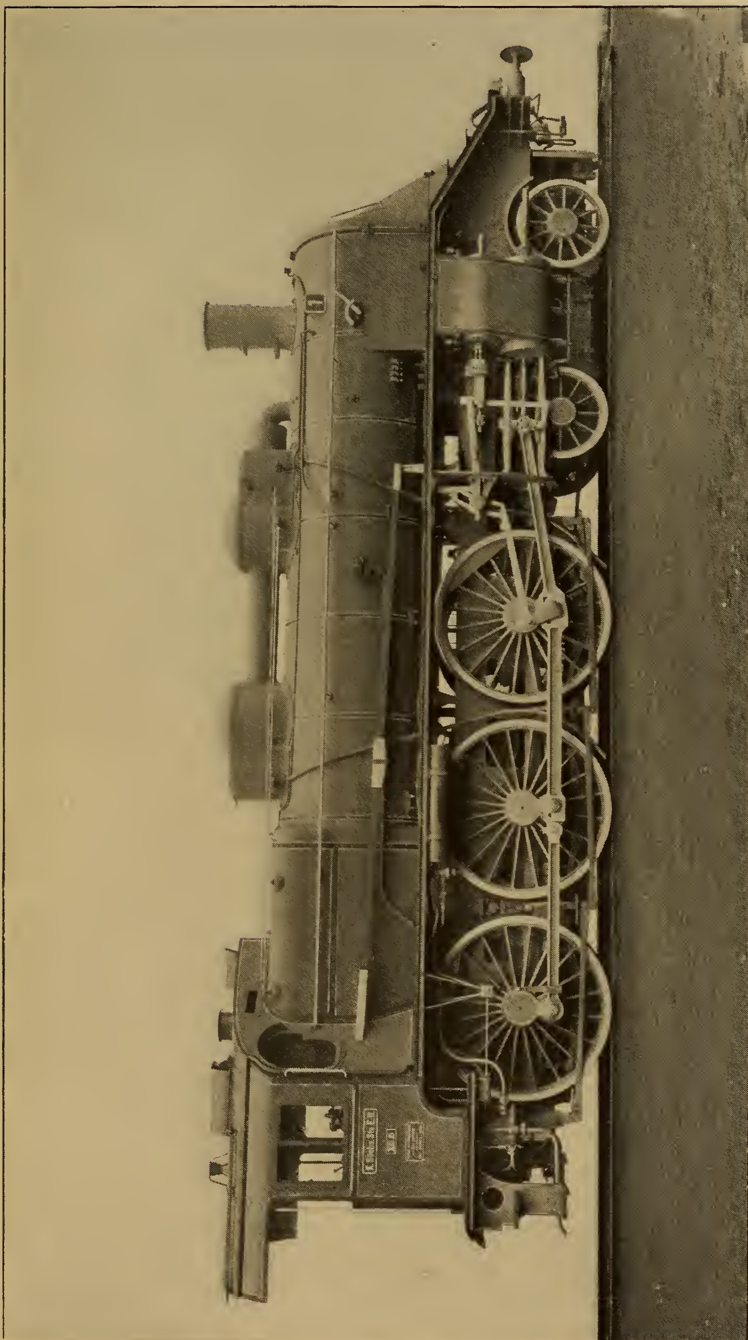


FIG. 21.—FOUR-CYLINDER NON-COMPOUND ENGINE, SAXON STATE RAILWAYS. SAXON ENGINE WORKS, CHEMNITZ

box with conical front and spark arrester is employed. In view of the climatic conditions—the photograph is taken during snow—a large enclosed cab is fitted, and a corresponding weather-board is provided on the tender. The front life-guards carry small snow-ploughs, as shown.

Fig. 18 illustrates a large engine for the 3 feet 6 inches gauge, constructed by Messrs. Stephenson & Co., Ltd., of Darlington, England, for the Burma railways. These engines are intended for the ordinary passenger traffic, slow and fast, and, as will be seen, they are fine examples of what can be done on lines of a comparatively narrow gauge. The boiler is provided with a Belpaire firebox and extended smokebox. These engines are provided with vacuum brake apparatus for controlling engine and train. In view of the climatic conditions the tender is provided with a cab, and both cabs can be fitted with sun blinds. The tender is provided with footboards on each side. There is also a corresponding class of engine adapted for mixed and goods traffic, which correspond in most particulars with the passenger engines described. They have steam brakes acting upon their own wheels, and an ejector for controlling the vacuum brake when used for a passenger train or with brake-fitted vehicles, but as they are used for secondary service they are adapted to burn wood fuel, and the tenders are fitted with a rail framework up to the level of the top of the tender cab.

The locomotive illustrated in Fig. 19 (for the Buenos Aires Great Southern Railway) is especially interesting as being the first four-cylinder balanced locomotive of British build in use in South America, and the first of such engines to be constructed in Great Britain for service elsewhere.

In 1904 the Vulcan Foundry, Ltd., supplied a four-cylinder compound 4-4-2 locomotive of their own design for use on the Great Northern Railway of England, and the system employed for the engine now under notice is a development of the design then employed. The system in use is practically a development of the de Glehn system, the outside high-pressure cylinders operating one pair of coupled wheels (the middle pair), and the inside low-pressure cylinders operating the leading coupled wheels and the valves, whereby the passage of live steam to the low-pressure cylinders through a reducing valve and the connection of the high-pressure exhaust to the chimney instead of to the low-pressure steam chest are controlled and operated by means of a small steam motor, controlled by the driver. In this case the driver's lever is so arranged that it changes automatically to compound as soon as the driver lets go of the lever.

The boiler is of large size, with a Belpaire firebox and extended smokebox. The Walschaert valve gear, reversed by means of the Vulcan Foundry patent apparatus, is fitted, piston valves being employed for the high-pressure cylinders and Richardson balanced slide valves for the low-pressure cylinders.

The locomotives of the class illustrated in Fig. 20 were introduced early in the year for working heavy fast express trains on the Great Western Railway of England, and they represent the present standard design except for the 4-6-2 engine already described, which is really developed from them.

Mr. Churchward's first four-cylinder engine was of the "Atlantic" type (No. 40, "North Star," built 1906), and this locomotive has been at work long enough to show its capabilities on the hardest and fastest work. All the latest express locomotives of the Great Western Railway are, however, six-coupled, and therefore the four-cylinder design is being extended in connection with six-coupled engines, twenty of which are now in service.

The inside cylinders are set some-

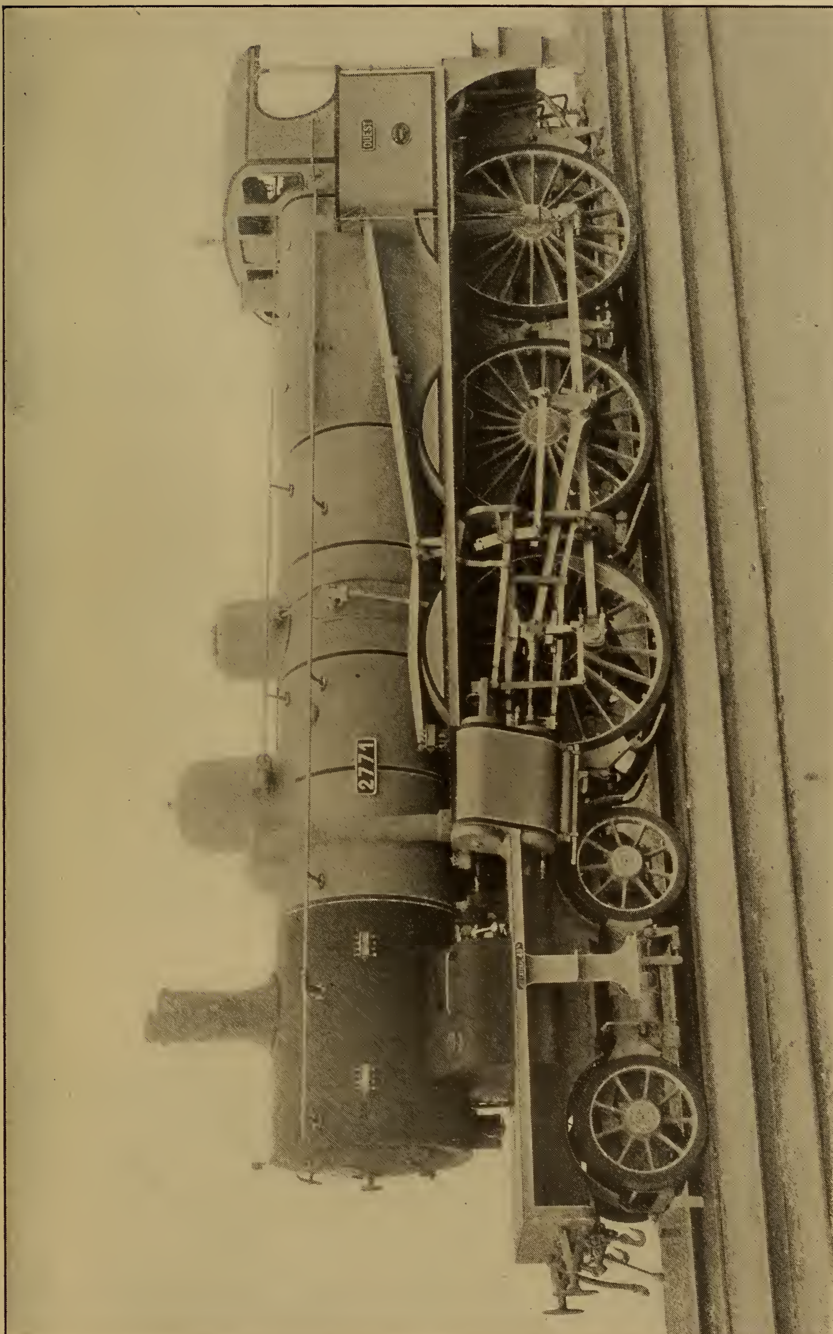


FIG. 22.—EXPRESS LOCOMOTIVE FOR THE WESTERN RAILWAY OF FRANCE. BUILT BY A. BORSIG, TEGEL, BERLIN

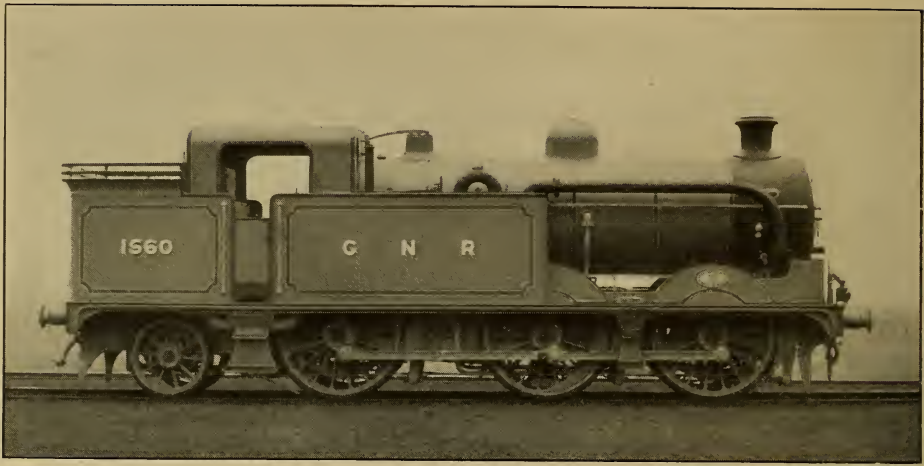



FIG. 23.—TANK ENGINE DESIGNED BY MR. H. A. IVATT FOR THE GREAT NORTHERN RAILWAY, ENGLAND

what forward of the smokebox, to provide sufficient length for the connecting rods, and the outside cylinders are correspondingly set back on the frames so that separate axles are driven. The valve motion is of the Walschaert type, arranged inside and consequently employing a single, large eccentric for each set. The inside valve rods are connected behind the inside cylinders through horizontally arranged rocking levers of the first order and link connections, with the front ends of the valve rods of the outside cylinders so that the valve rods of adjacent inside and outside cylinders are always moving oppositely. The valves are of the piston type now used almost exclusively on this line.

Some of the engines have been fitted with the Churchward superheater.

Although the employment of four high-pressure cylinders is a special characteristic of British locomotive


FIG. 24.—TANK LOCOMOTIVE FOR LONG DISTANCE SERVICE ON THE MIDLAND RAILWAY OF ENGLAND

practice it is not wholly so, and in Fig. 21 is illustrated a remarkable express locomotive recently constructed by the Saxon Engine Works of Chemnitz for heavy express duty on the State Rilways of Saxony, which also possesses this feature, all the cylinders being arranged to operate the leading coupled axle. The Schmidt superheater is fitted. There are several interesting constructional features, but these are well shown by the illustration.

Fig. 22 illustrates a new design of 4-60 express locomotives for the Western Railway of France, constructed by the firm of A. Borsig. The design is a development of the 4-6-0 engines, having coupled wheels, 5 feet 8 inches in diameter, already in use (de Glehn compound system), but in these cases the coupled wheels are larger (6 feet 4 inches), and the dimensions are also larger than in the older engines, so that the new locomotives are better adapted for the express service.

On the Great Northern Railway of England the tank engines for suburban traffic have been four-coupled engines, except for a series of 0-8-2 engines recently employed for working the passenger trains on the more heavily graded sections; but these latter engines have recently been sent to work heavy coal trains, and a new class of 0-6-2 engines introduced in their place, as being more suitable for passenger traffic and lighter on the track than the eight-coupled engines, while the larger size of the coupled wheels renders them more suitable for the fast work often required of them. One of these engines is illustrated in Fig. 23. They are fitted with condensing apparatus, as they work over a portion of the Underground Railway in London.

It may be mentioned, though we are not able to illustrate one of the engines, that a class of 2-6-0 engines with large coupled wheels and adapted for working express traffic has recently been introduced for use on some sections of the Italian State Railways.

FIG. 25.—COMPOUND EXPRESS LOCOMOTIVE. DANISH STATE RAILWAYS. HANOVER ENGINE COMPANY

Fig. 24 illustrates the first of a rather remarkable class of 0-6-4 tank engines recently introduced by Mr. R. M. Deeley for use on the Midland Railway. They are intended for heavy passenger service and have large fuel and water space. Some of them are fitted with water pick-up apparatus adapted for use when travelling in either direction. Refer-

FIG. 26.—EXPRESS LOCOMOTIVE FOR THE SWEDISH STATE RAILWAYS. NYDQUIST & HOLM, TROLLHATTAN, SWEDEN

ring now to the four-coupled engines, these designs are now so usual that reference is only necessary to a few special engines, the majority of the 4-4-2 and 4-4-0 express locomotives recently constructed corresponding to existing designs.

Although Continental locomotive practice has been characterized during recent years by a remarkable series of notable locomotives for various classes of work, Denmark has adhered to the ordinary and smaller designs until the advent of the new engines shown in Fig. 25. These are, therefore, of considerable interest, and the design also comprises several noteworthy features, though the dimensions are only of medium character as compared with those used for many of the large locomotives employed in other Continental countries.

The design has been prepared by Mr. O. Büsse, Chief Engineer of the Danish State Railway Administration, and the locomotive has been built by the Hanover Machine Works of Linden-bei-Hanover. The engine is a four-cylinder compound engine on the von-Borries system, with two outside low-pressure cylinders and two inside high-pressure cylinders, the steam distribution of each associated high and low pressure cylinder being controlled by a single, large piston valve of special design, operated by the Walschaert valve gear. The low-pressure cylinders actuate the rear pair of coupled wheels, and the inside cylinders the leading coupled axle. A peculiarity of the engine, in view of general Continental practice, is the fact that all valve gear is arranged inside the frames. The boiler is of fairly large size, and is fitted with a wide, round-roofed firebox and an extended smokebox. The cab is of the wind-cutter type, the safety valves passing through the cab

roof in the angle. The framing is an adaptation of the American style of bar framing. Brake gear is fitted to all the wheels. The tender is mounted on eight wheels, and these are not fitted in bogies as usual, and equalizing levers are employed between each pair.

The requirements of Swedish railways have so far been adequately met by means of 4-4-0 and 4-6-0 engines, but the locomotive engineers of that country have closely followed the practice of other countries, and Fig. 26 illustrates a remarkable locomotive of a trial character recently constructed by Messrs. Nydquist & Holm, of Trollhätten, Sweden, which comprises several interesting features. Inside cylinders are employed. The framing is largely of the cast-steel bar type, derived from American practice, but the framing of the leading bogie is rather unusual in construction. The boiler is large, with an extended smokebox, and a Schmidt smoke-tube superheater is fitted. The steam distribution is controlled by piston valves of the Schmidt type, adapted to be operated by Walschaert valve gear.

In conclusion reference is necessary to an interesting 4-4-0 engine recently introduced for trial on the Midland Railway, which comprises several interesting features.

Dating from a year or two before the close of Mr. S. W. Johnson's long tenure of office as chief mechanical engineer of the Midland Railway, there has been a marked change in the locomotive practice of this line, this change not being merely superficially apparent as regards exterior characteristics, but also as regards features of design and construction. The first express engines to exemplify the changes in locomotive practice were a series of 4-4-0 non-compound engines having large boilers, Belpaire fireboxes and involving many detail departures from previous practice, and these were followed by the first two, and then five, of the Smith three-cylinder compounds. Although these two classes have often been compared, sometimes somewhat to the disadvantage of the non-compound engines, though their performances have always been very fine and inferior only, perhaps, to the compounds, the two designs were very dissimilar, for the compounds were larger and had larger boilers and higher steam pressures than the non-compounds (usually referred to as the "Belpaires," though the compounds also have Belpaire fireboxes). Mr. R. M. Deeley, the present chief mechanical engineer, has continued both designs, there being a large

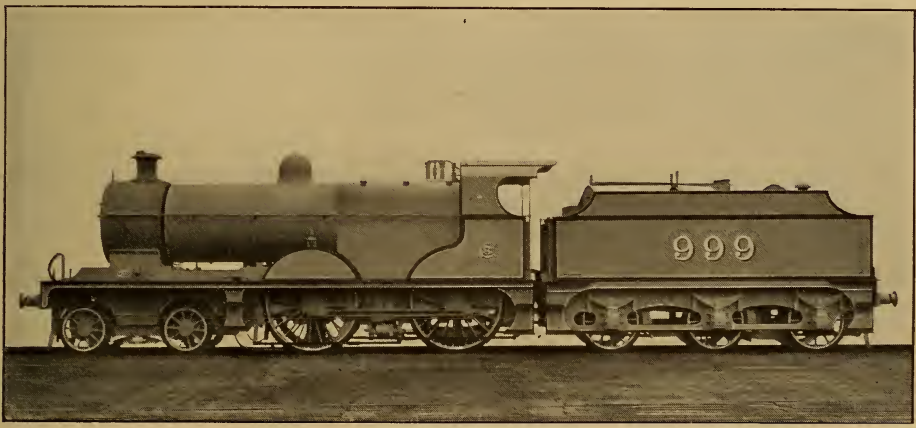



FIG. 27.—EXPRESS LOCOMOTIVE, MIDLAND RAILWAY, ENGLAND

DATA AND DIMENSIONS OF LOCOMOTIVES

| Fig. | COUNTRY. | RAILWAY. | Type. | Cylinders, Inches. | Coupled Wheels. | Heating Surface, Square Feet. | Steam Pressure, Lbs. per Sq. In. | Weight on Coupled Wheels, Tons (Engine). | Total Weight in Working Order (Engine), Tons. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | U. S. A...... | Erie............ | 0–8–8–0 | 25 x28<br>39 | 4′ 3″ | 5313 | 215 | 180¼ | 180¼ | Banking. |
| 2 | India......... | Burma......... | 2–6–6–0 | 14 x20 | 3′ 3″ | 1398 | 180 | 60½ | 60½ | 3′ 6″ gauge. |
| 3 | Arabia....... | Hedjaz......... | 2–4–6–0 | 12⅝ x22<br>20 | 3′ 4½″ | 1780 | 170 | 45 | 51½ | 3′ 6″ gauge. |
| 4 | Italy........ | State........... | 0–10–0 | 15 x26<br>24⅜ | 4′ 6″ | 1653 | 213 | .. | .. | |
| 5 | Greece...... | Private......... | 0–4–4–0 | 9 x15 | 2′ 3½″ | 508 | 160 | 30 | 30 | 2′ 5½″ gauge. |
| 6 | Ireland...... | L. & L. S. R.... | 4–8–0 | 15½x22 | 3′ 9″ | 1005 | 170 | 28 | 40 | 3′ 0″ gauge. |
| 7 | U. S. A...... | Southern........ | 2–8–0 | 22 x30 | 4′ 9″ | 3281 | 200 | 81 | 94 | |
| 8 | England..... | Lancashire and Yorkshire...... | 0–8–0 | 15½ x26<br>22 | 4′ 6″ | 1914 | 180 | 60¾ | 60¾ | 4-cylinder compound. |
| 9 | Asia Minor... | Ottoman........ | 0–8–0 | 19½x26 | 4′ 6½″ | 1786 | 180 | 58 | 58 | |
| 10 | Prussia...... | State........... | 0–8–0 | ...... | .... | .... | ... | .. | .. | Schmidt superheater. |
| 11 | Argentine.... | R. P. B. R...... | 0–8–0 | 19¾x24¾ | 4′ 1″ | 1330 | 170 | 62 | 62 | 5′ 6″ gauge, tank. |
| 12 | U. S. A...... | Pennsylvania.... | 4–6–2 | 24 x26 | 6′ 8″ | 4427 | 210 | 79 | 123 | |
| 13 | Mexico...... | National........ | 4–6–2 | 17 x28<br>28 | 5′ 7″ | 3713 | 220 | 65 | 101½ | 4-cylinder compound. |
| 14 | France...... | Paris-Orleans.... | 4–6–2 | 15½ x26<br>25½ | 6′ 0″ | 2777 | 227 | 52½ | 88 | 4-cylinder compound. |
| 15 | Malay....... | Federated Malay Straits........ | 4–6–2 | 15½x24 | 4′ 6″ | 1235 | 180 | .. | 45¾ | Metre gauge. |
| 16 | Italy........ | State........... | 2–6–2 | 14⅜ x26<br>23⅝ | 6′ 2″ | 2430 | 235 | 39¾ | 78 | 4-cylinder compound. |
| 17 | Sweden...... | Upsala-Gefles... | 4–6–0 | 18 x24<br>28 | 6′ 3″ | 1937 | 227 | 41 | 66 | 2-cylinder compound. |
| 18 | India........ | Burma......... | 4–6–0 | 15½x26 | 4′ 9″ | 1062 | 180 | .. | 35 | 3′ 6″ gauge. |
| 19 | Argentine.... | Buenos Ayres Gt. Southern.. | 4–6–0 | 14 x26<br>23 | 6′ 0″ | 1813 | 220 | 47½ | 69 | 4-cylinder compound. |
| 20 | England..... | G. W. R........ | 4–6–0 | 14¼x26 | 6′ 8½″ | 2142 | 227 | 55½ | 75½ | 4-cylinder simple. |
| 21 | Saxony...... | State........... | 4–6–0 | 15 x26¾ | 6′ 2¾″ | 2012 | 213 | 47 | 72¾ | 4-cylinder, simple, Schmidt superheater. |
| 22 | France...... | Western........ | 4–6–0 | 13¾ x25¼<br>21½ | 6′ 4″ | 2150 | 215 | 51 | 62 | 4-cylinder compound |
| 23 | England..... | Great Northern.. | 0–6–2 | 18 x26 | 5′ 8″ | 1249 | 170 | 51½ | 64¾ | |
| 24 | England..... | Midland........ | 0–6–4 | 18½x26½ | 5′ 7″ | 1331 | 175 | 52½ | 72½ | Tank. |
| 25 | Denmark.... | State........... | 4–4–2 | 13⅜ x23⅝<br>22½ | 6′ 0″ | 2201 | 220 | 31¼ | 66 | 4-cylinder compound. |
| 26 | Sweden...... | State........... | 4–4–2 | 20 x24¼ | 6′ 3″ | 1435 | 170 | 30 | 58 | Schmidt superheater. |
| 27 | England..... | Midland........ | 4–4–0 | 19 x26 | 6′ 6½″ | 1557 | 220 | 38¾ | 58½ | |

number of the "Belpaires" and a considerable number of the compounds now in service, though all except the first five compounds have Mr. Deeley's starting mechanism instead of that of the late Mr. Walter Smith, and these original engines have since been altered to correspond. The locomotive now illustrated in Fig. 27 is, however, a new design developed from that of the "Belpaires," but comprising several special features, and of such dimensions that a better comparison is afforded with the later series of the compounds which have larger boilers, and use a higher steam pressure than the original five. Only one engine of the new design is at present in service, as it is in many respects an experimental locomotive, but we understand that it is giving very good results on the heaviest work, usually working between Derby, Leeds, and Carlisle.

No. 999 has the inside cylinders

formed in one casting supporting the smokebox and the valves, which are controlled by a special valve gear of the piston type. To provide for limited side play of the driving axle, the connecting and coupling rods are provided with spherical brasses. The bogie is of the swing link type with pressed steel crossbars. A variable blast pipe is fitted.

It is fitted with a special valve gear, which has been patented by Mr. Deeley, and which is designed to obviate eccentrics. The valve movement of one cylinder is obtained from the cross-head of the other cylinder through the medium of an adjustable expansion link, and the lead is given by means of a pendulum link. A link is connected to the left-hand cross-head and rocks an upwardly extending arm connected to the pivot of the right-hand expansion link, which it oscillates. Similarly the left-hand expansion link is oscillated from the right-hand cross-head. The valve rod in each case is connected to a sliding block working in the slot of the appropriate expansion link, and at its other end is pivoted to a link whose upper end engages the valve spindle, and whose lower end is connected to a pendulum link, pivoted to the frame. The valve gear is adjusted by shifting the sliding block above or below the pivot of the oscillating expansion link in each case, and the levers for effecting these movements are so adapted, as shown, as to cause one sliding link to work above the pivot and the other below, or vice versa, for forward or backward gear.

A considerable number of other locomotives, more or less remarkable, could be described and illustrated, but from the foregoing it will be seen that the record of 1907 comprises a large number of really interesting locomotive designs, though few actual novelties, and the year must therefore rank as one of considerable importance, but there are signs that for some time to come locomotive practice will be steady and consisting more of ordinary development than of innovations.

The writer is indebted to the various locomotive-building firms whose productions are noticed, as in some cases to the officials of the railways concerned, for the illustrations and particulars given in the article.

The leading dimensions of the various locomotives illustrated are given in tabular form on page 36.

# THE NEW TURBINE YACHT ALEXANDRA

By A. C. Hurd

THERE have always been attached to the British fleet a number of yachts for the use of members of the Royal family and various departments of the government, and of late years a number of these vessels have had to be replaced by newer and more up-to-date ships. Shortly before Queen Victoria died an order was given for a new ship of State—the *Victoria and Albert*—of 4,700 tons and sea-speed of 17 knots, which cost something over half a million sterling. Unlike the German Emperor's yachts, this ship carries no guns, and the same is true of the new Admiralty yacht *Enchantress,* of 3,470 tons, which was launched at Belfast nearly five years ago, except that the latter has four small weapons for firing salutes. The Elder Brethren of Trinity House also have an official vessel, and small yachts are attached to the Portsmouth and Devonport and Nore commands for use by the port admirals in visiting the distant parts of their commands, and two despatch vessels are placed at the disposal of the commander-in-chief of the Channel and Mediterranean fleets for their personal use.

Now a further addition has just been made to the flotilla of official yachts by the completion of a new turbine-driven ship of 2,050 tons, which has been built by Messrs. J. & A. Inglis, at Glasgow. This ship has been given the name of *Queen Alexandra,* and will replace the old yacht *Osborne,* which was built at Pembroke nearly forty years ago, and is the last relic of the flotilla of wooden - paddle vessels, to which Queen Victoria always remained faithful, in spite of the progress of ship construction and marine engineering.

This new royal ship has been constructed at a total cost of £128,239, or £8,000 less than was originally estimated. She was designed by Sir Philip Watts, the Director of Naval Construction, and was laid down at Messrs. Inglis' yard on April 9, 1906, and has, therefore, been rather less than two years under construction. The *Alexandra* is 275 feet long, with a beam of 40 feet and a mean load draught of 12 feet 6 inches. Her turbines have been manufactured by the Parsons Marine Turbine Company, she has been fitted with Yarrow boilers, and has a speed exceeding 18¼ knots. She is a small ship, which is intended primarily for coastal service by the King and members of the Royal family, and is, therefore, of shallow draught. The *Alexandra* is built with a topgallant forecastle and a bridge deck, 150 feet long, extending to the sides of the ship and carried on stanchions from the main rail. The pavilion or deckhouse contains the reception room, dining-room and pantry, while abreast of it are two small tea houses, which have a clearer view ahead and astern and also over each side. The King's smoking-room is under the bridge, and also rooms for the commander of the vessel, the officers and the surgeon, as well as the ship's hospital, or sick bay. An elegant stairway will give access to the bridge or promenade deck. On the main deck abaft the turbine room are the Royal apartments, rooms for His Majesty's secretary, equerries, and others. The cabin servants are berthed aft on the main deck, the

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THE LAUNCH OF THE ALEXANDRA

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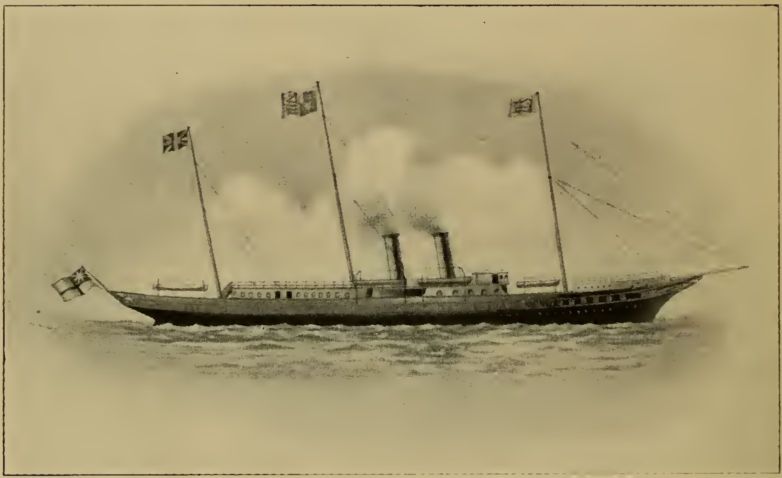
THE STERN OF THE ALEXANDRA SHOWING RUDDER AND PROPELLERS



THE ROYAL TURBINE YACHT ALEXANDRA



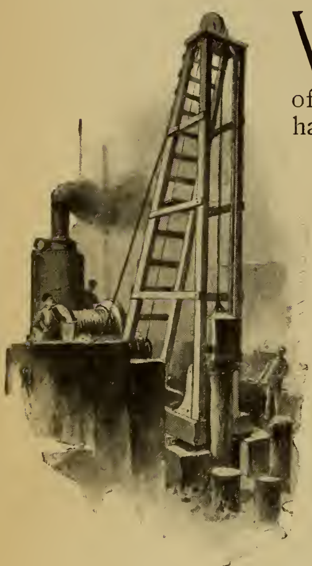
THE BOW OF THE ALEXANDRA AFTER LAUNCHING.

warrant officers abreast of the funnel hatch; the Royal kitchen comes immediately in front of the boiler space; next is the ward-room and officers' cabins, and, forward of all these, the crew's quarters. The forecastle contains the crew's galley, lamp rooms, and wash places, etc., for seamen and firemen. On the lower deck is additional crew space, auxiliary machinery and various storerooms, the magazine and baggage rooms. She is rigged as a three-masted schooner and has two funnels. The trials of the *Alexandra* were a great success, and were especially noticeable for the absence of vibration.

The illustrations include interesting photographs showing the launch at the yard of Messrs. J. & A. Inglis & Co., at Glasgow, also the bow of the vessel, just after launching, and a view of the stern, showing the balanced rudder and the three screw propellers.

# CONCRETE PIER CONSTRUCTION ON THE PACIFIC COAST

By H. A. Crafts



WHARF-BUILDING on the Pacific Coast of the United States has always been attended with grave difficulties, especially in connection with the use of wooden piling. This class of piling is not only affected by the action of the sea-water, but it is also subject to the continual attacks of the very destructive marine insects known as the *teredo* and the *limnoria*.

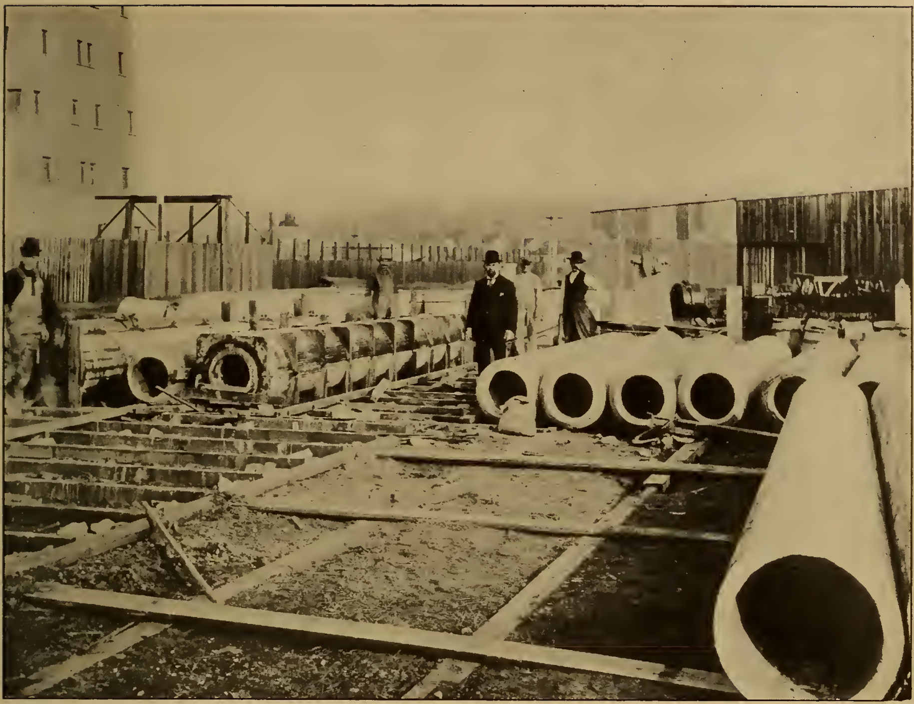
Various expedients have been tried to protect the piles from the ravages of these insects, including treatment of the timber by various chemical solutions, or its protection by the use of incrustations, and even by steel armour; but these have shown themselves of doubtful value. More effective have been the attempts to introduce concrete piles, and among the most successful systems of this kind may be noted the combination wooden and concrete pier system devised by Mr. Howard C. Holmes, a well-known engineer, of San Francisco.

This system has now been in use on the San Francisco water front for more than ten years, and during that time it has proved itself very satisfactory. The piers are termed "wooden-cylinder" piers, but this name does not indicate the real character of the construction, since it is actually a form of reinforced concrete, the wooden cylinder being used merely as a formative appliance. The wooden cylinder, however, is allowed to remain as a part of the pier until it is destroyed by the elements, before which time the concrete has become the indestructible portion of the construction.

The operation of making a wooden-cylinder pier, as followed on the Pacific Coast, is commenced by forming a wooden core by driving one or more piles, three being the usual number. These piles are driven in a close group until a firm foundation is reached in the deep mud which is usually encountered. These piles need not necessarily be all driven to the same depth, nor need their tops all be on the same level. If the tops of the piles do not reach fully to the top of the completed pier any space occasioned by the shortage may be filled by concrete in the finishing of the work.

The object of this wooden core is to secure a solid foundation, and also to increase the elasticity of the pier at the point of maximum lateral stress, which lies at the mud line. In practice, it has been found that the friction between the mud and the piles can be depended on absolutely, so far as the sustaining power of the foundation is concerned, the mud bottom in San Francisco harbour being of unknown depth.

After the core, or cluster of wooden piles, has been placed, there is driven over it a wooden-stave pipe, this usually having an inside diameter of 4 feet. This pipe is made of staves of Oregon pine, 3 to 4 inches in thickness, bound together with iron hoops provided with adjustable lugs. The



CASTING THE CONCRETE CASINGS AT THE FACTORY

hoops are spaced about 2 feet apart from centre to centre, and fitted so that the cylinder is entirely watertight. This cylinder is driven to its foundation by an ordinary pile-driver, being sunk from 10 to 15 feet into the mud bottom. After this the water is pumped out, and also a portion of the mud, leaving a difference in level of 2 to 5 feet between the mud on the inside and outside of the pipe.

In the annular space between the central core and the inside of the cylinder there is then placed the metallic reinforcement, consisting of expanded metal or some similar metal web, this forming a cylinder about 1 foot less in diameter than the interior of the wooden cylinder.

All this is preparatory to the making of the concrete pier itself, the operation being completed by filling the interior space with a rich concrete of hydraulic cement and broken rock. There is thus a completed cylindrical pier, consisting of a strong and elastic wooden core, surrounded with a mass of reinforced concrete, proof against the attacks of marine insects, the whole being protected for at least four years by an iron-bound wooden jacket. The tops of the piers are capped with structural steel I-beams, upon which the superstructure of the wharf or dock is erected.

Piers of the above construction are in use to a large extent on the waterfront of San Francisco; but recently another type has been developed by the Pacific Construction Company from the designs of Mr. F. A. Koetitz, an example of this construction being found in a new wharf near the foot of Filbert street, on the sea wall. In this system the external wooden cylinder is replaced by a cylinder or casing of reinforced concrete, the interior core of wood being retained, although but one core pile is used in each pier. The in-

terstitial web of metal is also omitted, the reinforcement being entirely contained in the concrete casing.

There are a number of interesting features about the manufacture of these casings and the setting of the piers. The casings themselves are 24 inches outside diameter and 20 inches inside, the walls thus being 2 inches in thickness. The reinforcement is made of steel rods wrapped in metallic coils, and imbedded in a medium, slow-setting character, the core is left in the mould for at least a day, while the outside form is not removed from the upper part for two days, the lower part not being taken off for about a week. The concrete casings thus formed are removed to storage, where they are allowed to harden for one or two months, according to the nature of the concrete. The completed casing thus consists of a tube of reinforced con-

CONCRETE PILE CASINGS READY FOR USE

concrete composed of one part of Portland cement to three parts of aggregate. These casings are manufactured some distance from the proposed wharf, the form being laid in a horizontal position and the concrete being made sufficiently wet to be poured in through an opening in the upper side. After the concrete is poured in the mould is well shaken, both to insure the settlement of the material and to aid in the separation of any air bubbles which might have formed. As the cement used is of crete, 24 inches outside diameter, with walls 2 inches thick, the length being 22 feet.

The operation of constructing a pier is as follows: The central wooden core, consisting of a pile of Oregon pine 16 inches in diameter, is driven, the depth of water being 15 feet, a bottom of rip-rap being provided, and the pile driven to a firm foundation. Over and surrounding this pile a length of concrete casing is lowered and driven into the bottom for a depth of 7 feet. Before

DRIVING A CONCRETE PIER-CASING

driving the casing a wooden pilot, armed with a heavy steel shoe, is driven into the rip-rap, in order to make an opening sufficiently large to receive the concrete casing. The casing is also fitted with a shoe on the lower end in order to facilitate the driving, this shoe also acting as a guide and excluding, as much as possible, the entrance of mud or sand through the bottom. In the construction of the wharf referred to above, the tops of the casings were driven to a depth 2 feet lower than the height required for the superstructure, and the adjustment in height was made by clamping wooden forms around the tops of the casings and filling them with concrete to bring them to the proper height.

The casings are driven with a common pile-driver; but in order to avoid excessive jarring, a wooden cap is used, this consisting of a ring of three thicknesses of sole leather placed upon the top of the casing, surmounted by a hardwood cap about 6 inches thick. A short iron cylinder is bolted to the wooden cap, this cylinder being fitted with a piston carrying another wooden cap, the cylinder being filled with sawdust. The main driving cap placed upon the upper block consists of a 3-inch iron plate, with a 5-inch pin, upon which the ram of the pile-driver falls, the action of the blow being thus centred.

After the concrete casing is driven it is pumped out, and the annular space between it and the wooden core is filled with concrete. Such piles are found to be entirely impervious to the attacks of the marine insects, while combining the strength of the reinforced concrete and the elasticity of the wooden core, and thus being superior to either form alone.

# THE EFFICIENCY OF STEAM TURBINES

By F. A. Lart

ONE of the results of the various articles published in the engineering journals upon the performance of the steam turbines in the steamships *Mauretania* and *Lusitania* has been to call attention to the actual and possible economies effected by this particular form of steam engine, especially as compared with performances of older types, represented by the reciprocating engine, a form by no means yet defunct.

We need not here consider any other forms of steam turbine than the Parsons system, with which the *Mauretania, Lusitania* and numerous other sea-going vessels are fitted, as this is at present the only one in practical sea-going use, so far, at any rate, as British shipping is concerned. It is not to be necessarily inferred from this fact that the system in question is either the only practicable one, as regards large power developments, or the most economical turbine system extant, or otherwise, and generally speaking, the best.

The immediate results (from the point of view of speed economy in steam consumption) which crowned the application of this particular system to high-powered steamships and other forms of power developers and users have been confirmed, and the enterprising initiative of successive marine engineers and steamship owners, including the Admiralty, have been more than justified by these latest successes and supreme installations of the new Cunarders.

It may have been noticed that in some quarters, and by certain German engineering authorities, official and creditable or otherwise, some skepticism has been evinced as to the actual utility, economy and efficiency of the turbine system, for marine power purposes especially. But it would appear that the criticisms levelled against the turbine principle, and the Parsons system in particular, have been based either on misapprehension of actual facts or inadequate information and knowledge as regards the theory of the subject.

As regards the production of steam for the Parsons or any other turbine system, whether for marine or other power purposes, nothing special requires to be said here; and it may be taken for granted that, as regards the efficiencies of boilers, the quality of water to be evaporated and the economical consumption and duty of the coal fuel used, the best available plant and methods have been duly installed on board the *Lusitania* and *Mauretania*.

The quality of steam, by whatever means produced, is in itself invariable, except so far as its dryness and, consequently, reduced tendency to loss pressure, power and efficiency through condensation, can be, and nowadays usually are, improved by the simple process of superheating.

So far as the consumption of steam, superheated or otherwise, is concerned for any specific output of gross or net "horse-power," it is hardly claimed for the turbine, of the Parsons or any other type, that it is an economical engine either actually or relatively to other forms of steam-power engines. Such relative economy may, however, be developed and obtained in the future, in all stages, or some or one particular stage, of

the conversion of the boiler water into net power as represented by the driving effort and the efficiency of the screw propellers. In these latter, also, may possibly lie hitherto undiscovered efficiencies and possibilities of improvement.

The steam in a turbine, because it is a steam engine in which the thermo-dynamic properties and value of the steam (and ultimately, or primarily, of the coal fuel consumed) are converted by the natural laws of expansion of gases, which are inherent in steam as one of them, into actual work and power output, is obedient to the same laws and follows much the same course of action as obtain in the ordinary and more familiar reciprocating type of steam engine. That is to say, it exerts and develops kinetic energy upon and in the mobile mechanism upon which it is brought to bear.

A steam turbine is nothing more nor less than a continuous cylinder, piston, crank and crankshaft combined, and comprises, therefore, four of the five fundamental and essential details of a reciprocating engine. The only difference is that in the turbine both a simplification and a complication of one or other of these elements are effected. The cylinder of the reciprocating engine—of limited length and, therefore, "stroke"—is, in the turbine, converted into a cylinder of infinite length. The reciprocating piston of the one is converted into a continuous piston, or multiplicity of pistons, of infinite and unchanged direction of motion in the other; and the single crank actuated per piston becomes in the turbine a multiplicity of cranks continuous and infinite, having no dead centres, and of "throw" equal to the varying mean peripheral diameters of the multiplicity of small piston blades composing them.

The piston and crank become, in fact, one and the same thing, and the cylinder diameter may be said to be represented by the length of the "stator" or working steam chamber of the turbine. The area of the rotary crank piston is the total area of the rotor blades as acted upon by the steam and calculated in a plane rectangular to the rotary movement of the blades, i. e., parallel and radial to the axis of the cylinder and crankshafts.

The piston and connecting-rods, slide-bars and blocks and valve gear complete disappear altogether. The alternate, reciprocating, action of the pistons and their alternate thrust and pull upon the cranks, one of each per crank revolution, with crank leverages varying from zero to a maximum value and thence back to zero at each half revolution of the crank, give place, therefore, to a continuous, greatly multiplied and constant crank leverage effort upon the crankshaft, from and directly by which such leverage effort is transmitted to the screws and overcomes the resistance offered by their rotary propulsive action in the water, which constitutes the net or useful work performed by the steam.

The action of the steam in a turbine necessarily differs somewhat from its action in an ordinary engine; not, of course, thermo-dynamically, but by reason of its thermo-dynamic properties being applied and made use of in a somewhat different mechanical manner. The application and action of steam in both the reciprocating and the rotary "turbine" engine is twofold, viz., (1) impact, and (2) expansive. In the reciprocating engine the impact lasts only during a limited proportion of the stroke, according to the duration and cut-off of the steam admission; and this proportion of steam admission relative to the complete stroke of the piston and crank determines the degree of expansive working which the steam thereafter solely performs. It should not be lost sight of that this duplex action of steam does take place in reciprocating engines, though some would appear to think that the action of the steam is a purely expansive one throughout, irrespective of the

degree of cut-off. The primary impact action of steam during admission is, in fact, an important and most valuable one, as it renders available the highest possible kinetic energy of the steam, though not with any corresponding mechanical and power advantages, since the crank lever is at such a period in the position of minimum leverage length for utilizing the power behind it and exerting a proportionate amount of actual work. Also, this maximum kinetic energy of the steam is only available at the commencement of each piston stroke, when the piston velocity is increasing towards its maximum, and not usually at mid stroke, when the piston velocity is greatest, and never at the finish, when the crank-leverage value and effort fall away to the zero they started from. It is, therefore, only twice per revolution of the crank that this particular advantage is available.

The remainder of each piston stroke is effected purely by the expansive energy of the steam, and as this falls away, under natural laws, in a fixed mathematical ratio represented approximately by the parabolic curve, we have again, at the end of each stroke, when the crank-leverage value is falling to zero, the unfortunate accompaniment of a practically corresponding cessation of the propulsive energy of the steam and piston.

Further, we have the mechanical defects (1) that the piston speed falls away to zero at the same time and in the same ratio as the cessation of the crank-leverage length, and (2) that the period of maximum crank-leverage, which is approximately mid piston stroke, corresponds exactly to the period of maximum piston velocity, and that at such critical position or period, when the maximum kinetic energy of the steam would be most effective, the steam effort available is a decreased and diminishing one, proportionate in degree, respectively, to the degree of cut-off of the steam admission and ratio of its expansive working.

We have, therefore, against us in the reciprocating steam engine a formidable array of natural and inevitable disadvantages, both thermo-dynamic and mechanical.

The steam turbine, though by no means either mechanically or thermo-dynamically perfect, affords a means of avoiding or mitigating some of the disadvantages possessed by the reciprocating steam engine, and, at the same time, has some other, inherent, advantages. So far as mechanical considerations go, we have seen that all disadvantages of moving parts, their inequalities of working and their multiplicity disappear completely in the turbine, and with them disappear most, if not all, of the thermo-dynamic difficulties and losses induced by them. Against these several and combined economies must be set whatever thermo-dynamic or mechanical disadvantages are possessed by, or induced in, the rotary steam engine which we call the turbine. As regards mechanical points, the concentration in the turbine of the various masses of the reciprocating engine into two main essential components comprising all of them and all the mechanics necessary to produce power in conjunction with the thermo-dynamical agent steam, effects considerable saving in weight and space involved in the production of the unit of power, and entails a net simplification of detail matters, in spite of the multiplicity of these details.

The action of the steam in the turbine differs from that in the reciprocating engine in that it is continuous and both impact and expansive throughout, both impact and expansive efforts becoming reduced as the steam travels to the exhaust, on account of, and proportionately to, the fall in its pressure, and consequently decreased velocity of movement combined with its increased volume. These changes are accommodated so as to counteract the decreased propulsive rotary effort of

the steam as much as possible, by increasing the volume of the cylinder, the area and peripheral (mean) velocity of the piston blades, and consequently their leverage or crank lengths, to a degree proportionate, as near as possible, to the parabolic curve of adiabitic expansion.

This continuous flow of steam has the fortunate advantage of keeping the temperature of the whole mechanism at a constant maximum, with such consequent decreased tendency to condensation as balances the obstructed traverse and energy of the steam, both impact and expansive, and its consequent tendency to fall in pressure and temperature and to be condensed as it passes over the numerous rotor and stator blades.

In the turbine, as in almost all high-power steam engine plants except locomotives, the exhaust steam passes into a vacuum, as high as can be maintained, which is equivalent to 30 inches of mercury, or 15 pounds per square inch pressure.

It is thus possible to completely exhaust the kinetic energy of the steam in useful work, instead of, as in locomotives and other non-condensing steam engines, obliging the steam to complete its work and to be released into the atmosphere at a pressure necessarily slightly above, or at least not less than, the pressure of the atmosphere itself, approximately 15 pounds per square inch. Unless the steam does possess this pressure and its attendant energy, it is obvious that it is prevented or hindered from escaping readily into the atmosphere, and thus thwarts the impact and expansive energy of the steam which is still doing work in the rear of it by creating back-pressure. In non-condensing steam engines, i. e., those in which the steam finally escapes into the atmosphere and against whatever pressure that atmosphere may at the moment possess, as indicated by the barometer, this atmospheric pressure has to be deducted from the initial, or boiler, pressure which the steam possesses at the commencement of its work; thus, steam raised to a boiler pressure of 185 pounds per square inch has virtually only a pressure of 170 pounds per square inch. But in a condensing steam engine the exhaust steam escapes not into the atmosphere at all, but into a chamber cooled with and containing water and having all or as much as possible of the air extracted from it, so that it forms a vacuum into which the steam can flow readily, however low its pressure and energy may have fallen in the course of its work in the cylinder, and without any hindrance. Therefore, according to the completeness of the vacuum maintained, and up to the perfect vacuum of 30 inches of mercury (barometric), equivalent to 15 pounds per square inch of atmospheric pressure, the initial or boiler pressure of the steam is correspondingly enhanced. In the steamships mentioned, the initial boiler pressure is 180 pounds per square inch, and the steam exhausts into a vacuum of 28 inches, equivalent to 14 pounds per square inch of pressure (atmospheric), so that actually the initial steam pressure, or that immediately available in the high-pressure cylinders or turbines before expansion commenced, was $180 - 1 = 179$ pounds per square inch.

It will be obvious that, to obtain this degree of vacuum, or any other, work requires to be performed *pro tanto*, either by the main engine itself or by some auxiliary power; and, therefore, the added efficiency imparted by the vacuum exhaust to the steam driving the main engines, and consequently to the engine itself, is, to some extent, neutralized. Nevertheless, the net gain is a very considerable one, and, therefore, quite wipes out the cost at which it is obtained. This is one of those seemingly paradoxical conditions of the thermo-dynamics of steam which are found to exist and to be of much practical value in steam-engine working. We shall notice another similar

one of this character further on.

It is the aim of the marine engineer, as of others, to increase the efficiency of turbine and all other forms of steam engines to the utmost, so that of the known or calculable thermo-dynamic value of the coal or other solar fuel employed to create potential steam power in boilers, which is thence converted into kinetic mechanical energy and so into actual work of propulsion or traction, or whatever kind may be desired, he may obtain the highest possible percentage, as expressed in terms of such actual net work performed.

To effect this, both the engine itself and the steam brought to bear upon it must possess the highest possible efficiency. In the first case this is directly represented by the percentage of actual net useful work which is converted by the engine from the known or calculable potential thermo-dynamic value of the unit or bulk of steam brought to bear upon it, usually estimated as per unit of time. As matters now stand to-day, this percentage (mechanical) efficiency of the steam engine is not a high one, though it varies according to the particular type. The lowest efficiencies are possessed by locomotives and other non-condensing engines; the highest efficiencies by condensing engines running at fairly, but not extremely, high speeds in the case of reciprocating engines, and by turbine rotary engines of various types, including the Parsons; and in any case by employing the steam on the compound principle of double, triple or (if economically feasible) quadruple expansion in as many differene stages.

In the *Lusitania* and *Mauretania* this complete exhaustion of the kinetic energy of the steam is effected in fifteen different stages, commencing with the high-pressure turbines, which, working at 194 revolutions per minute during trials, received steam at a pressure of 150 pounds per square inch absolute, i. e., inclusive of the 28 inches of vacuum (— 14 pounds per square inch) at the condenser. The boiler pressure was 180 pounds, showing a fall between the boiler and the high-pressure admission of 30 pounds per square inch, equivalent to an effective loss of 16 pounds per square inch, due probably to friction and radiation in the delivery pipes, and, to some extent at least, unavoidable. The mean pressure available during these fifteen stages was about 35.5 pounds per square inch absolute, the gauge pressure of the steam at the exhaust being about 1 pound per square inch.

By thus adding to the actual boiler pressure of the steam in condensing steam engines, the atmospheric pressure available at the moment, or as much of it as possible according to the efficiency of the air-pump and condenser which create it, there is a considerable gain of power, and by utilizing the utmost possible kinetic or expansive energy of the steam it is possible to effect a further economy by using a smaller quantity of steam for any given amount of power output. This is effected in reciprocating engines by an early cut-off of the steam admission at each stroke. In the turbine which has no automatic, mechanically-actuated valves (except the governor valve controlling the supply of steam *pro rata* with the speed) the supply of steam, degree of cut-off and ratio of expansion can only be controlled by the main admission valve; actually, of course, there is no cut-off, the continuous movement of the engine requiring a continuous feed. But obviously more steam can be supplied to the engine through the delivery or throttle valve than it actually requires to do the work allotted to it, in which case the kinetic exhaustion of the steam will necessarily be incomplete, and it will finally exhaust into the vacuum of the condenser, not at zero or any inappreciable pressure, but at a comparatively high and kinetically efficient one. On the other hand, if too little steam is admitted

at the throttle the engine will simply fail to do its work. The proper and accurate indication that the turbine engine is getting its proper supply of steam and that it is doing the known quantity of work required of it is the ascertained number of revolutions it is making per minute, combined with the ascertained pressure of the steam at each of the successive stages of its expansive working, including that at the exhaust, as shown by the gauges.

It is on this latter principle of multiple-expansion and ultimate kinetic complete exhaustion during and not after the performance of work that the steam turbines convert the potential energy of the coal fuel and the kinetic energy of the steam into mechanical work of ship propulsion, etc. The actual efficiency of this system or of these particular engines is not accurately determinable, but is undoubtedly a high one, both as regards the purely mechanical efficiency of the engine and the thermo-dynamic efficiency of the steam, and as regards both combined.

But even if these two essential conditions of efficiency in any steam engine are fulfilled, there still remains the efficiency of the steam generators to be considered; and this is evidently the keystone or absolute foundation of the whole problem, inasmuch as the useful work finally obtained from the engine and propellers, or driving wheels or pulleys, or whatever other means are employed to express or give out that work, is clearly dependent on and directly measurable in terms of the thermo-dynamic properties of the coal or other fuel employed in the steam-generating plant. Taking coal as the most ordinary and most convenient and (though variably) thermo-dynamically valuable fuel, its total thermo-dynamic value, as measured in terms of actual useful work, or of any intermediate work at any stage of its conversion from the one to the other, can be determined. What percentage of such valency will ultimately be obtained—that is, what degrees of efficiency the intermediate steam-generating, steam-working and mechanical-working, or what degree of efficiency the whole necessary plant combined may develop in practice—is another question altogether. The efficiency of any steam plant, and especially the ultimate mechanical efficiency as represented by the amount of useful work which can at any time be obtained from it, is, therefore, directly dependent on the potential or inherent thermo-dynamic solar efficiency of the coal or other fuel from which such power is directly derived, though by indirect means of conversion.

We have so far reviewed the principal mechanical means of economically utilizing the kinetic energy of the steam and converting it into useful work outside the engine itself. The steam turbine, as has been shown, dispenses with practically all the mechanical defects of the reciprocating engine, and, therefore, avoids the serious losses of mechanical and of thermo-dynamic steam efficiency which they represent. This in itself is a considerable gain, and quite sufficient, other things being equal, to justify the use of the turbine principle for purposes of power production wherever and whenever feasible; and the steam turbine has the peculiar advantage that, in almost any and every conceivable case, it can not only be put down in place of any other type of existing steam plant, but, in being so substituted, effects considerable economy in space and general convenience as compared with the plant it displaces. There remains the question of the thermo-dynamic efficiency of the steam itself as developed in the generators and as delivered to the engine where its potential kinetic energy is to be transformed into gross and net, or actual useful work. The possibility of improving the potential kinetic energy of the steam is equally important; and it is at least equally capable of attainment with ease and economy in

the whole engine, as will be seen.

The first essential of economy in steam is that it shall preserve throughout both its admission and its expansive career the same quantity of heat which it possesses when it leaves the boiler, or, at any rate, when it enters the cylinder of the engine, which heat is the measure and expression of its kinetic energy. That is to say, the curve of expansion should be not only adiabatic, i. e., mathematically expressive of the changing but correct relations of pressure and volume arising from the expansive working of the steam, but also isothermal, i. e., showing no loss of total heat during and at any stage of this expansive working, although the fall of specific temperature necessarily coincides with the fall of pressure.

It has already been pointed out that the constant flow of steam through the turbine, and especially if it is regular in quantity, assures a constancy of temperature throughout proportionate at every stage to the varying pressure of the steam. In other words, the range of temperature throughout the working portion or cylinder of the turbine is a regular curve corresponding precisely to the curve of falling pressure and increasing volume. So far as possible, therefore, these several conditions are obtained, and hence the comparatively high efficiency, mechanical and thermo-dynamic, of the turbine form of steam engine.

A very simple and effective method of assuring these thermo-dynamic conditions in the steam turbine is now available, viz., the Field-Morris system of preserving the specific heat of steam and assuring its absolutely correct adiabatic and isothermal expansion when doing work, and of, therefore, increasing and prolonging its kinetic energy during expansion by aëration and superheating. This simply consists in mixing with the steam coming from the boiler a suitably proportionate quantity of air, compressed up to the boiler pressure, and, therefore, heated automatically and raised, by passing it through some additional heating medium, such as the exhaust steam or waste boiler gases, up to approximately the same temperature as the steam. The mixture of steam and compressed air is then superheated, and in this state delivered direct to the working cylinder.

By this simple process, which involves only some slight addition and no sort of complication to the working steam plant, steam users derive all the benefits of ordinary superheating, and, in addition, the thermodynamic value of highly compressed and very hot air.

There is already ample proof that, in this Field-Morris aërated steam, we have an absolutely ideal thermodynamic agent or motive fluid for turbine and steam engines and all other types, whether condensing or not. The theory of this perfect isothermally and adiabatically expansive motive fluid, as well as the practical application of it, prove equally conclusively that steam is once again to be regarded as the most efficient and economical power agency which nature has placed within the reach of man. Here, indeed, we have an absolute concrete, natural illustration of the law of conservation of energy, and also of the extraordinary quality of auto-reproductive energy. From the unit of such power agency, therefore, is to be obtained the absolute equivalent in gross, if not in net, working results. Some losses there must necessarily be—those of mechanical friction, of radiation, of leakage, perhaps, and so on. But with all this we have the simple, demonstrable and irrefutable fact that the potential kinetic energy of this Field-Morris aërated steam is completely expressed in terms of equivalent work done; and the higher the degree of the efficient work performed by the steam in the mechanical power-transformer, i. e., the engine, whether turbine or reciprocating, the higher correspondingly is the efficiency of

the power turned out by and available from the machine.

The point necessarily presents itself how this aërated steam is likely to affect, or to be affected by the presence of, the vacuum of the condenser in condensing engines. As regards non-condensing engines, the apparently, and, to some extent, actually, contradictory conditions of the former case do not apply; and the means of economy of steam consumption are obvious, since the non-condensing properties of the superheated, aërated steam enable a much earlier admission cut-off to be maintained, a much smaller quantity of steam (as from the boiler and as part of the mixture), and also of the mixture itself, as compared with natural steam, to be used, and a higher ratio and a more reliable curve of kinetically efficient expansion to be obtained.

The use of this very simple superheated mixture of compressed air and steam effects, therefore, a three-fold economy, as compared with the use of ordinary steam, superheated or otherwise, in ordinary non-condensing engines, whether their cylinders are steam-jacketed or not. In fact, the only means of effecting any economies in the working of non-condensing steam engines have hitherto been the superheating of the wet steam from the boiler and the steam-jacketing of the cylinders. Both these methods are also applicable to, and quite successful in, condensing engines, both of the reciprocating and the rotary turbine types; but steam-jacketing, unless very efficiently carried out, is apt to be uneconomical in the long run, for various reasons.

Now as regards the use of this aërated steam in condensing engines, the objection evidently occurs that it must become so much more difficult to maintain an efficient vacuum, or indeed any at all, when the exhaust consists partly of air. In the second place, the function of the air is partly to jacket the steam and, through its own non-conductive properties, to prevent the radiation and loss of heat from the steam with which it is intimately mixed. Therefore, it becomes so much the more difficult to condense the steam. This joint difficulty involves the decided objection, therefore, that the vacuum and condensing plant requires to be much larger than with ordinary steam, and of the utmost efficiency; that is, if the same advantages of vacuum exhaust are to be maintained. But it can be easily shown that the advantages of vacuum exhaust and condensation, as regards supplementing the initial boiler pressure of the steam and facilitating or ensuring its complete and effective kinetic exhaustion by expansion in the working cylinder, can be just as well obtained solely through the use of this superheated aërated steam mixture without any vacuum exhaust or condenser at all, unless, as is usual in marine engine work, a condenser is necessary for supplying the boilers with feed-water. Assuming that a condenser is indispensable, then it would be most economical, if not absolutely necessary, to combine it with a vacuum and the necessary air-pump plant. But the same high degree of vacuum usually required or sought for when ordinary steam is used does not necessarily require to be used with aërated steam. Effective condensation is, however, none the less desirable on account of the greater difficulty, already referred to, of condensing this refractory mixture. This very property of the preservation of heat possessed by this mixture of air and steam, which is so beneficial, thermo-dynamically, in the working cylinder, becomes a disadvantage when the exhaust passes to the condenser. We have, therefore, to weigh the gain of the one against the disadvantage or actual loss, if there is any, of the other. But we have, on the one hand, as we have seen, a three-fold gain in the use of this aërated steam at the outset. And as the quantity to be used per unit of power output, both of

boiler steam and of aërated steam mixture, is much reduced, there is obviously less work for the condenser and vacuum pump to do per unit of power output. We may say at once that the quantity of steam taken from the boiler to produce this unit of power output is reduced by 25 per cent. at least, as compared with ordinary superheated steam.

The air mixed with it costs nothing; neither does the necessary compressing of it to the boiler steam pressure cost anything, since such expended power is (a) more than reproductive, according to natural laws, and (b) performed, in any properly arranged plant, by the aërated steam mixture itself. Nor does the superheating of the mixture cost anything if effected, as, of course, it should be, by the waste furnace gases.

Now it has been proved, by careful and exhaustive experiments, that the unit volume of this superheated aërated steam is possessed of at least 25 per cent. higher kinetic or thermodynamic value than ordinary steam adequately superheated.

Suppose, then, that we consider the actual economy to be effected on the unit basis (kinetic) of 1,000 indicated horse-power. The kinetic efficiency of the superheated, aërated steam being 25 per cent. higher than that of superheated ordinary steam, we shall require only $1{,}000 - \frac{5}{1{,}000}$ $= 800$ I. H. P. Of this, again, we require 25 per cent. less steam from the boiler, or 600 I. H. P. in all. In other words, 600 unit volumes of superheated aërated steam are equivalent to 1,000 unit volumes of superheated natural steam, which represents a total saving of 40 per cent. This saving may be translated directly into equivalent economies of water and coal (or other fuel) consumption.

Now assuming that the work thrown on the condenser and air-pump is increased in total 50 per cent. per unit volume of aërated steam dealt with; and assuming, again, that with ordinary superheated steam the work done or engine power absorbed by this condensing plant is 10 per cent. of the engine power on any unit basis, then 10 per cent. of 1,000 I. H. P. = 100; increased by 50 per cent., this becomes 150 I. H. P. This represents actual expended power. Reduced to the 40 per cent. more efficient aërated steam power, we get an expenditure, in those terms, of $150 \times \frac{5}{7} = 107$ I.H.P., about. This must be deducted from the above-mentioned net engine efficiency, i. e., added to the net I. H. P., so that we get 707 unit volumes of superheated aërated steam as the kinetic equivalent of 1,000 unit volumes of ordinary superheated steam, equivalent to an economy of $\frac{1{,}000 - 707}{10} = 29.3$ per cent. for any condensing steam engine.

This is a very appreciable net saving.

Now let us suppose that it is, for any reason, impossible in a marine or any other engine plant to have a vacuum and condensing plant, so that the engine is non-condensing and the exhaust has to take place into the atmosphere and against a normal barometric pressure of 15 pounds per square inch.

The initial boiler pressure of 180 pounds per square inch, which is also that of the superheated air and steam mixture, then becomes $180 - 15 = 165$ pounds per square inch, or a reduction of 8.3 per cent. The 1,000 I. H. P. referred to above is, therefore, reduced in efficiency to this degree; then, to obtain the same amount of kinetic energy, there will be required $1{,}000 + 83.3 = 1{,}083.3$ I. H. P. of ordinary superheated steam. Using the 40 per cent. more efficient

aërated steam mixture, this quantity becomes only $1{,}083.3 \times \frac{5}{7} = 773.6$ I. H. P., about, instead of the 707 I. H. P. required in the condensing engine, or an increase of 9.42 per cent. That is, ordinary superheated steam is approximately 8.3 per cent. less economical, and superheated aërated steam 9.42 per cent. less economical, in a non-condensing than in a condensing engine: or in the ratio of 1 to 1.13—an advantage of 13 per cent. in favour of ordinary superheated steam. This must be deducted from the 40 per cent. higher economy of the superheated aërated steam, which thus becomes 27 per cent. in the case of non-condensing engines, as compared with 29.3 per cent. in condensing engines.

We are thus able to prove that, in spite of the decreased (50 per cent.) economy of the vacuum and condensing plant which we may fairly assume to accompany the use of this aërated steam, this Field-Morris system is even then capable of showing a net economy of steam, water and coal or other fuel consumption of no less than 27 per cent.

We may fairly take these figures of 27 and 29.3 per cent. as having been already proved (and actually exceeded) bv practical application of the system to steam power plants working on ordinary and reasonably efficient lines, and which should bring about those economies in engineering practice which are necessary to the manufacturer who is faced with the ever-growing costs of labour and materials.

# THE SIX-CYLINDER AUTOMOBILE

By Herbert L. Towle

MUCH printer's ink has been shed during the past few months in discussions of the respective merits of four and six cylinder automobiles. Some of this has been futile, special pleading by persons interested in the production of the one or the other type, and candor will not refuse to admit that some of the claims made on both sides have been, to put it gently, somewhat specious. Is there not room for a sober analysis of the intrinsic qualities of the two types?

Since the real question is whether a four or six cylinder motor is preferable for certain service, it is obvious that equal powers, rather than equal bore and stroke, are to be compared. In other words, suppose one wants a 30-horse-power car, will a four or six cylinder car of that power do the work better? Which will be cheaper? Which will have the greater range from high to low speed? Which will be the pleasanter to drive? Which will be freer in the long run from breakdown and repairs? Which will be easier on tires? These are the questions which interest the purchaser. Reflection will show that it is possible to answer nearly all of them with some degree of definiteness by reference to the established characteristics of the two types.

The best-known fact about the six-cylinder automobile motor is its freedom from vibration. Vibration is of two kinds: that due to the unbalanced motion of the reciprocating parts, and that due to the reaction of the engine from the intermittent impulses produced by the explosions. The inertia forces of the reciprocating parts of a vertical engine act vertically upward during the upper half of the stroke and downward during the lower half. Owing to the angularity of the connecting rods, the upward and downward inertia forces are not equal, the former being greater and the latter longer continued. In Fig. 1, curve *A* shows for a car speed of 40 miles per hour the inertia piston of a single piston, wristpin, and upper end of a connecting rod in a typical automobile engine, the Franklin type D, rated at 28 horse-power. The bore is $4\frac{1}{2}$ inches and stroke 4 inches, and the gear ratio is $3\frac{1}{2}$ to 1 with 34-inch wheels. The piston, rings, and wristpin weigh 4 pounds five ounces, and the upper end of the connecting rod weighs 1 pound 4 ounces. Curve *B* of the same diagram shows the opposing inertia forces in an adjacent cylinder; and the difference between these curves, multiplied by 2, gives the unbalanced forces in four cylinders at once, as shown by the curve *C*. We thus see that with the engine running 1,400 revolutions per minute, as in the case considered, the unbalanced inertia force reaches 552 pounds at the beginning, middle, and end of each stroke, and is reversed 5,600 times per minute, or 93 times per second. Although the force is momentary, it is sufficient, even in the short time it acts, to produce a very considerable tremor, which extends the whole length of the car. The engine complete weighs 470 pounds, or much less than the amount of the unbalanced force referred to.

In a six-cylinder engine the reciprocating parts, if properly weighed

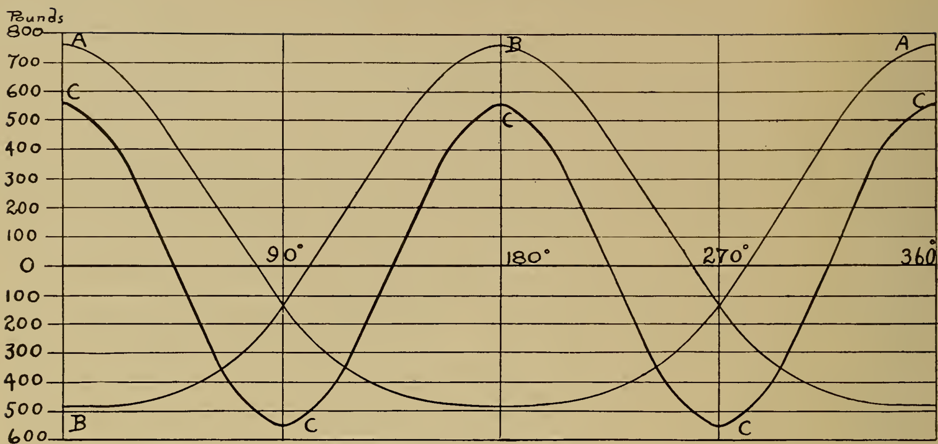



FIG. 1.—INERTIA CURVES OF RECIPROCATING PARTS OF FOUR-CYLINDER MOTOR

and balanced against each other before assembling, are in practically perfect balance, whether standing or running. Except, perhaps, with the largest sizes, the passenger in the "six" has no consciousness of the engine except by sound and by its response to the throttle. Not only does this contribute largely to the agreeable sensations of riding, but it augments materially the life of the engine and the forward parts of the car. The destructive effect of "racing" a four-cylinder engine is well known, and needs no further elucidation than the typical figures given just above.

Now let us consider the torque reaction. Fig. 2 shows the curve for four consecutive strokes of a single cylinder, taking both gas pressure and piston inertia into account. Fig. 3 shows four such curves for a four-cylinder engine, and the sum of the four is shown by the heavy curve in the same diagram. In Fig. 4 we have, to the same scale, the separate and combined torque curves of six similar cylinders, from which it is seen that the variation in torque reaction is far less. It is to be remembered in all cases that it is not the force, but the change in the amount or direction of the force, which produces vibration. Short, quick impulses produce less vibration than slower impulses of the same intensity, separated by correspondingly longer intervals. Again, the possibility of synchronism between the vibration of the engine and the natural vibration period of the springs is to be considered, though this is a factor only at the lowest speeds.

We will now apply these considerations to a representative case. A four-cylinder engine of $4\frac{1}{4}$ inches bore and 5 inches stroke will develop from 25 to 30 horse-power at 1,200 revolutions per minute; and a six-

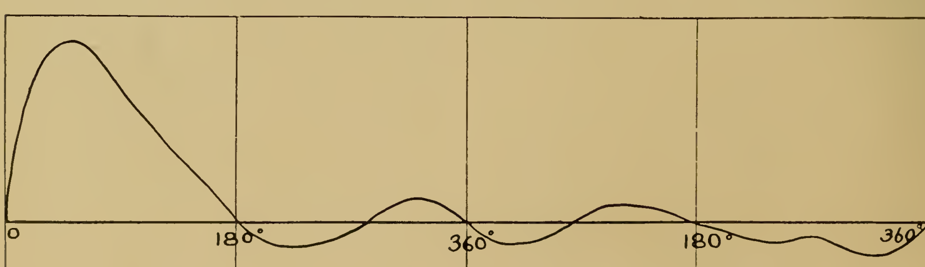



FIG. 2.—TORQUE CURVE FOR ONE CYLINDER

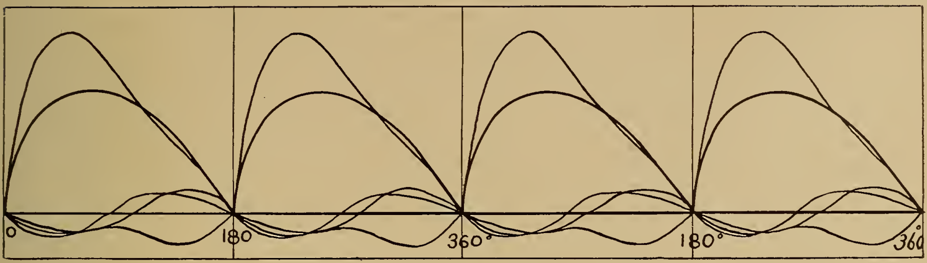



FIG. 3.—TORQUE CURVE FOR FOUR-CYLINDER MOTOR

cylinder motor, $3\frac{1}{2}$ inches bore by 4 inches stroke, will develop the same power at 1,500 revolutions per minute, which represents the same piston speed. Now, for one cylinder the

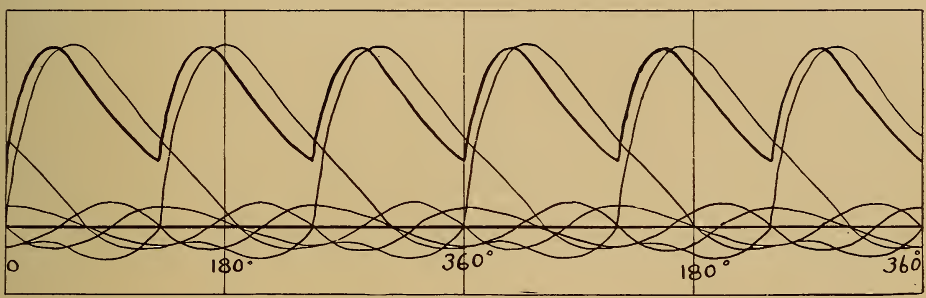



FIG. 4.— CURVE OF NET TORQUE OF SIX-CYLINDER MOTOR AT FULL ROAD SPEED

turning moment will be proportional to the product of the stroke and the square of the diameter, or, individual impulses alone being considered, the ratio will be as 88 to 49. But the six-cylinder motor gets $7\frac{1}{2}$ impulses, while the four-cylinder motor gets four, and the impulse of the former overlap. The curves of torque reaction at full speed are shown approximately for the two cases in Fig. 5. They fully explain the characteristic "smoothness" of the "six."

Let us next examine in the same manner the flow of the air in the carbureter. For this purpose we may without material inaccuracy ignore the angularity of the connecting rod; and, neglecting this, we find the velocity of the piston to be represented by a sine curve. It starts

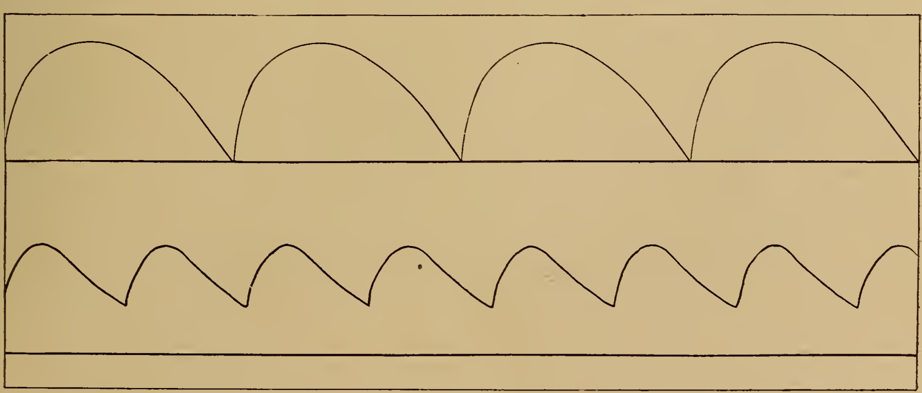


FIG. 5.—COMPARATIVE TORQUE CURVES OF FOUR-CYLINDER AND SIX-CYLINDER MOTORS OF EQUAL POWER

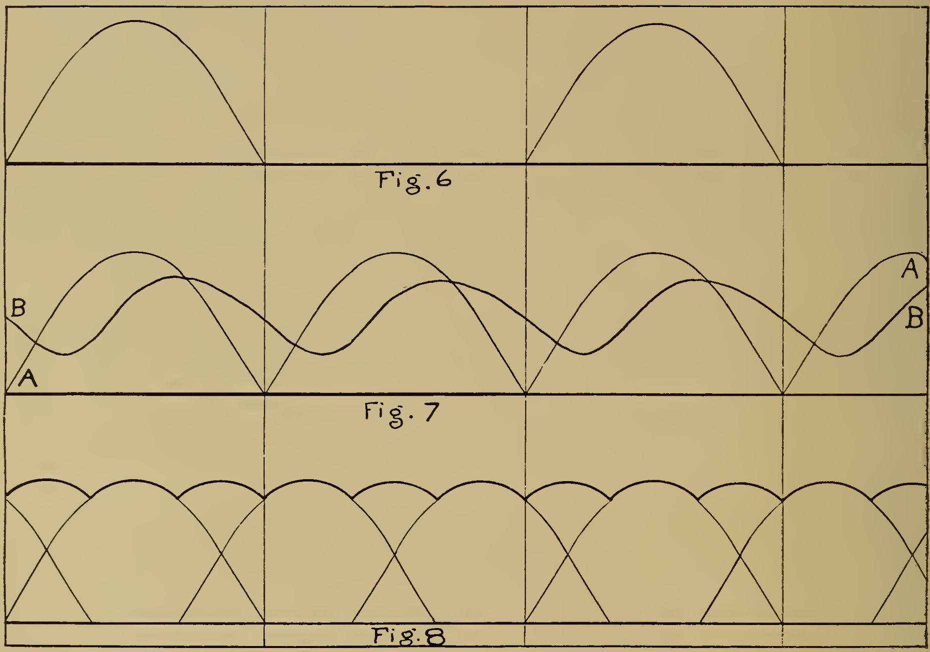



FIG. 6.—CURVE OF AIR VELOCITY OF TWO-CYLINDER MOTOR DISREGARDING INERTIA

FIG. 7.—PISTON AND AIR VELOCITIES OF FOUR-CYLINDER MOTOR AT MODERATE SPEEDS

FIG. 8.—SEPARATE AND COMBINED PISTON VELOCITIES OF SIX-CYLINDER MOTOR

at zero, increases first abruptly and then more slowly to the maximum at mid-stroke, and then slackens in the same manner to the end of the stroke. If the air in the carbureter followed exactly the velocities of the piston (*i. e.*, if it had no inertia), the curve of air velocity of a two-cylinder engine would wear the appearance shown in Fig. 6. At low speed the peaks would be low, at high speed they would be high, but the zero line of no velocity would intervene between every two suction strokes. Now, it is known that any form of commercial carbureter requires some minimum air velocity to make a proper mixture. Some carbureters require a higher velocity, others a lower, but the minimum is always there. Again, no carbureter will adapt itself instantly to extreme changes in air velocity, and it is a very good carbureter indeed that does not need, when the throttle is suddenly opened, all the grace that the inertia of the air column will give it. Obviously a carbureter which is not very flexible can give only an average mixture for a two-cylinder engine, and the throttle must not be too abruptly opened when the motor has been running slowly. Fig. 7 shows at *A* a similar curve for a four-cylinder engine. Curve *B* represents the fluctuations in velocity which the air stream may be supposed to undergo at moderate speeds. At medium to high speeds any carbureter will perform satisfactorily, since then the curve of air velocity tends to straighten out, owing to inertia. At very low speeds, however, the case is quite different, since then only the peaks of the curve of air velocity may come up to the maximum working speed of the carbureter, all the rest of the curve being too low. Obviously this condition fixes the minimum limit of speed for the car, since the attempt to run so slowly results in back firing and stoppage of the engine.

In Fig. 8 are given in light and

heavy lines the separate and combined curves of piston velocity for a six-cylinder engine. It is seen that here the air velocity at no time somes anywhere near zero, and, moreover, it is almost a straight line even at the slowest engine speed. This represents the most favourable condition possible for efficient vaporization of the gasoline, and shows clearly why the "six" may be slowed down actually to a foot pace, and accelerated similarly in high gear, without slipping the clutch and with a perfect mixture throughout the stroke; also why the "six," running no faster than a man's brisk walk, will climb in high gear a grade which the "four" of the same power would not touch, save at several times the speed or in intermediate gear. The real reason is simply that the carbureter is delivering continuously a stream of perfect mixture, and the cylinders are completely filled with this perfect mixture, instead of with stratified charges whose several portions may be too rich or too lean.

Both the smooth running and the extreme flexibility of the "six" have from the driver's point of view a significance which goes much beyond its purely technical aspect. The average automobile of to-day is too obtrusively mechanical; it is not a perfectly docile servant; it controls better at medium to high speeds than at low speeds, and the temptation of the driver is to display his cleverness in driving, rather than let his passengers enjoy their outing in the same manner that they would if the car's management required only nominal skill. The fact that one can see little or nothing of the country when traveling fast would tempt the motorist to drive slowly if he could do so with ease; but since he cannot do this, his tendency is to forget the country and think only of pushing the car to its utmost. Thus it follows that a car both flexible and so quiet in its operation that its crude mechanical features do not thrust themselves on the passenger's attention will exert a strong psychological influence against high speeds

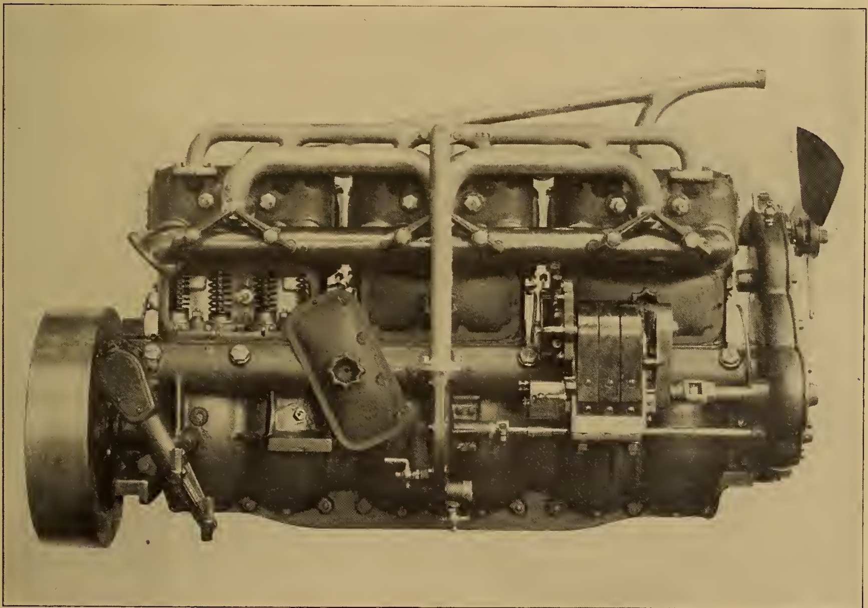


FIG. 9.—WINTON SIX-CYLINDER MOTOR, SHOWING ARRANGEMENT OF COVER PLATE OVER VALVE MECHANISM

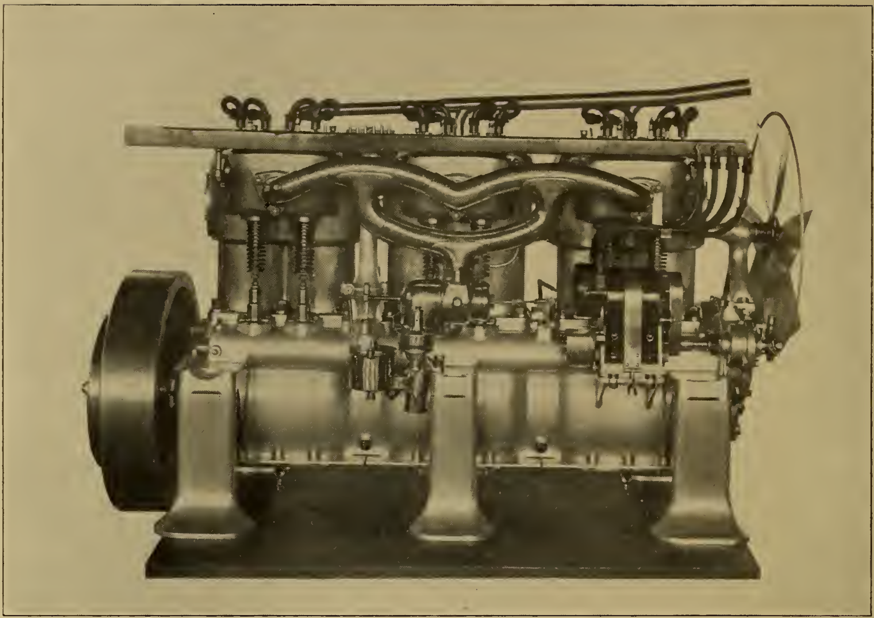


FIG. 10.—SIX-CYLINDER, 60 HORSE-POWER MOTOR OF PEERLESS MOTOR CAR. INLET SIDE, SHOWING CARBURETER, MAGNETS AND HIGH-TENSION CABLE BAR

by making moderate driving attractive.

The six-cylinder motor has practically fifty per cent. more working parts than the four. Undeniably that means fifty per cent. more things to wear out. On the other hand, a motor is only one of many elements of the car, and none of the other elements are multiplied at all. Again, keeping in mind the fact that we are considering equal powers, not equal bore and stroke, we see that the motor parts will be enough smaller to offset in a measure their added number by their lessened cost of manufacture. As for "complication," in the sense of increased difficulty, it does not exist. There are more bearings to be lined up, more valves to be timed and kept tight, and more spark plugs to be supplied with current; but that is about all.

Concerning the cost of the complete car, it is sufficient to say that the difference will be negligible when both types are manufactured on an equal basis. The smooth running of the "six" will permit certain reductions to be made in the strength of parts now subject to deterioration in the "four." Among these are the radiator, the clutch, and the transmission gears and shafts. The wheel base of the "six" will be slightly longer, but, again comparing equal powers, this also will be slight.

Some early six-cylinder cars were greatly over-weighted in front, because the builders had not found how to lighten the engine. These cars made poor hill climbers, and developed skidding and lack of traction on muddy roads and in snow. Power for power, however, a correctly designed six-cylinder motor is no heavier than the four-cylinder, largely because of the great saving in the flywheel weight.

The question of ignition is a little more difficult, as measured by four-cylinder standards. Magneto ignition, which at this time seems to be preferred on most of the better class of four-cylinder cars, is hard to adapt to the "six," on account of the limited arc of advance which can be allowed it on that type of motor.

For this reason most six-cylinder cars are at this time equipped with battery ignition and trembler coils. It is well known that it is next to impossible to "tune" the tremblers of a four-unit coil alike, and still more impossible to keep them so. The effect of variable trembler lag is to make the time of ignition variable, and when there are six cylinders to be timed alike, the loss in power from unequally tuned tremblers is so great as to force the adoption of the "synchronized" coil and secondary distributor. In this system a single-trembler coil is used, a timer closes the primary circuit through this coil for three times per crankshaft revolution, and a revolving distributor sends the secondary current from the coil to the several spark plugs in order. Thus only a single trembler is used, and whatever its adjustment may be, the timing is alike in all the cylinders.

The only objection to this arrangement is the rapid consumption of the battery and the rapid wear of the trembler contacts, which need constant adjustment. It is well known that the ordinary trembler makes several sparks for each ignition, whereas but one is required to fire the charge. Fortunately, an ignition system is now available whereby but one spark per ignition is produced, and this spark is due to a positive contact of the briefest possible duration, so that no current is wasted. This system has been successfully applied to six-cylinder cars, and has shown high economy, using only dry cells, the smallest and most convenient source of current extant.

The questions of durability and repairs, which have been left for the close, will naturally exert a strong influence in determining the final choice between the two types. The fact above alluded to, viz., that the "six" is practically exempt from wear and tear due to engine vibration and irregularity of driving impulses, weighs heavily in its favour. It may be expected that the automobile of the future will be so constructed as to concentrate most of its wear into certain easily renewable

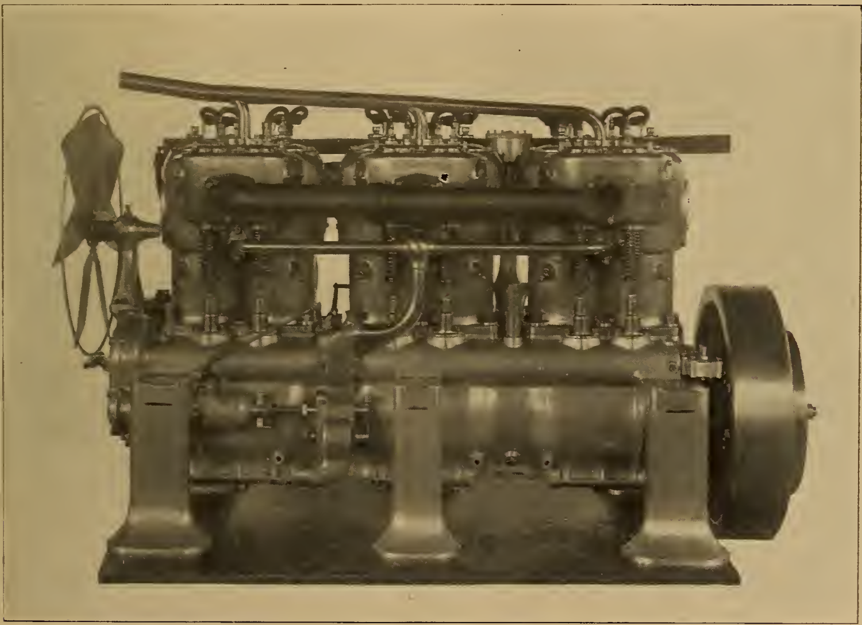


FIG. 11.—PEERLESS SIX-CYLINDER MOTOR, 60 HORSE-POWER. EXHAUST SIDE, SHOWING PUMPS AND GOVERNOR CASE

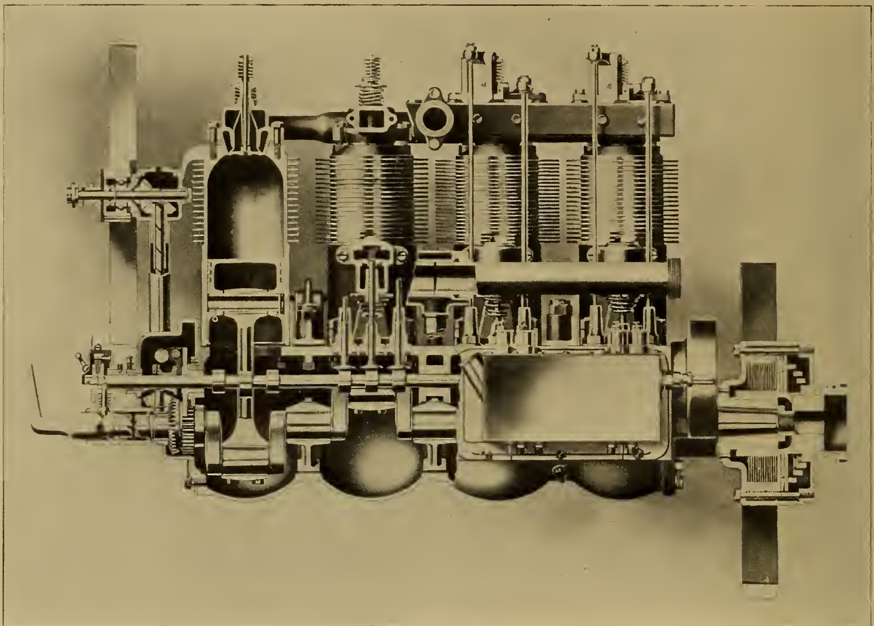


FIG. 12.—FOUR-CYLINDER AIR-COOLED MOTOR, PARTLY IN SECTION. CONCENTRIC INLET AND EXHAUST VALVES IN CYLINDER HEAD. H. H. FRANKLIN MFG. CO.

parts, so that the cost of overhauling and repairing the future car will be materially less than it is to-day. There is no feature of the "six," except the added moving parts of two cylinders, which intrinsically costs more to repair than the "four." On the other hand, the life of the car

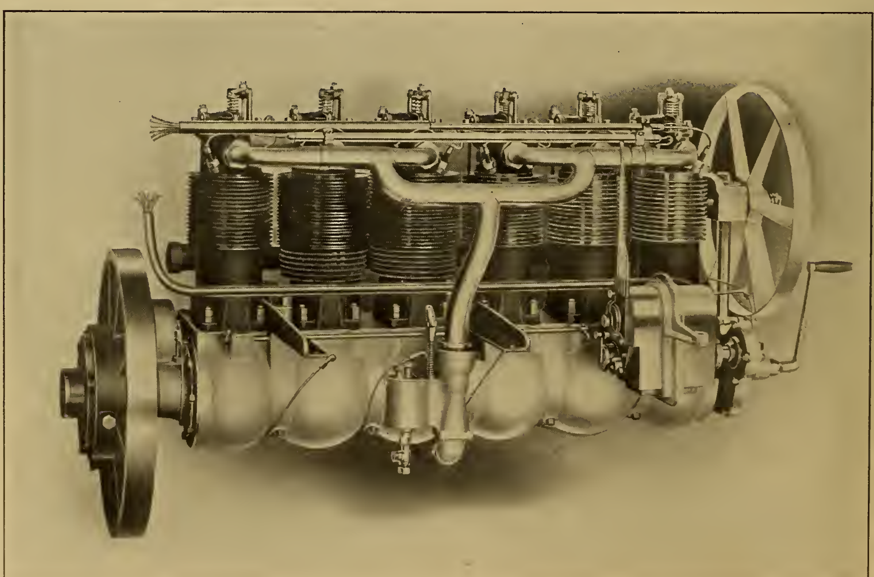


FIG. 13.—SIX-CYLINDER AIR-COOLED MOTOR, 42 HORSE-POWER. INLET SIDE, SHOWING CARBURETER AND MAGNETO. H. H. FRANKLIN MFG. CO., SYRACUSE, N. Y.

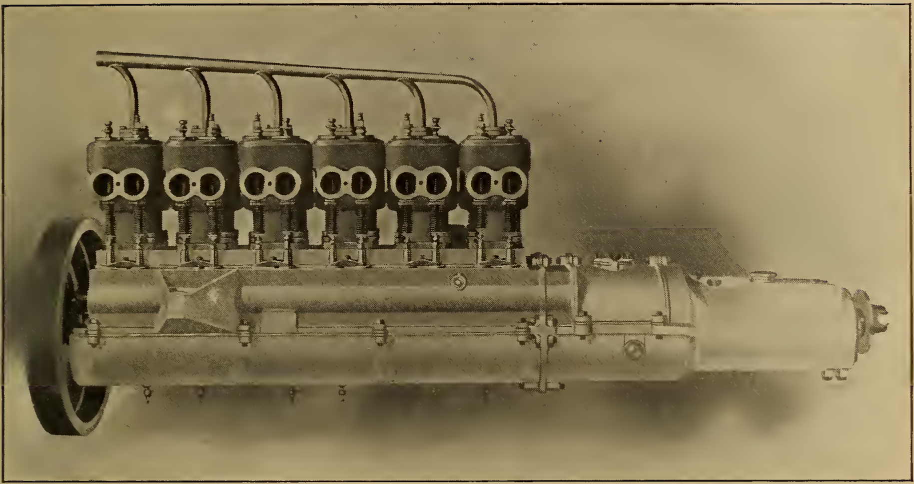


FIG. 14.—STEVENS-DURYEA SIX-CYLINDER ENGINE AND SPEED-CHANGING GEARS IN CONTINUOUS CASING SUPPORTED AT THREE POINTS

as a whole may be expected to be materially greater, and this will in many cases turn the scale in favour of the "six." When we recall that depreciation, whether measured on the basis of the car's supposed total mileage or taken as the difference between its prices at first and second hand, is almost always the largest single item in the keeping of an automobile (certainly the largest after tires), it is clear that whatever features of design, within reason, will reduce depreciation are entitled to most careful consideration.

In the matter of tire cost, it is

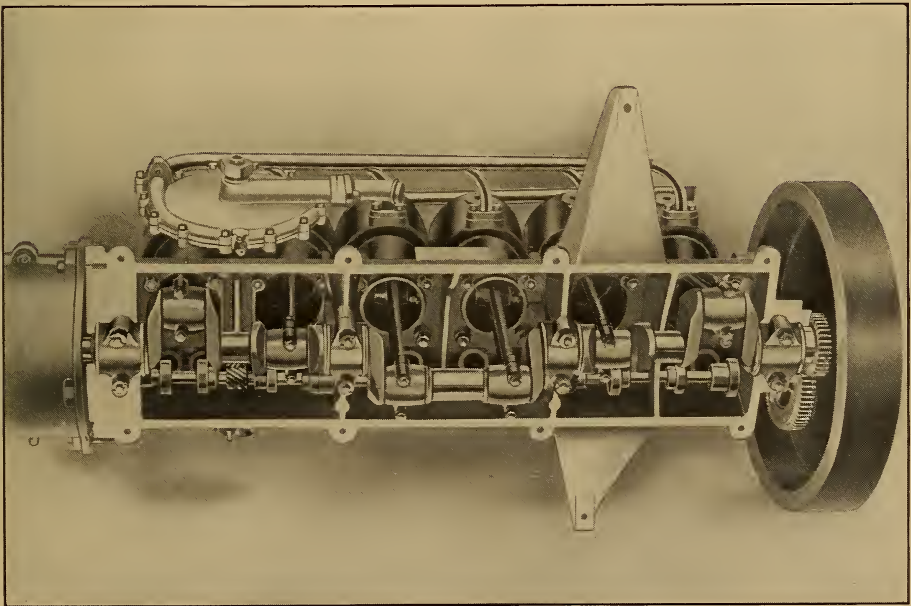


FIG. 15.—BOTTOM VIEW OF STEVENS-DURYEA SIX-CYLINDER MOTOR, WITH OIL PAN REMOVED, SHOWING CRANK SHAFT

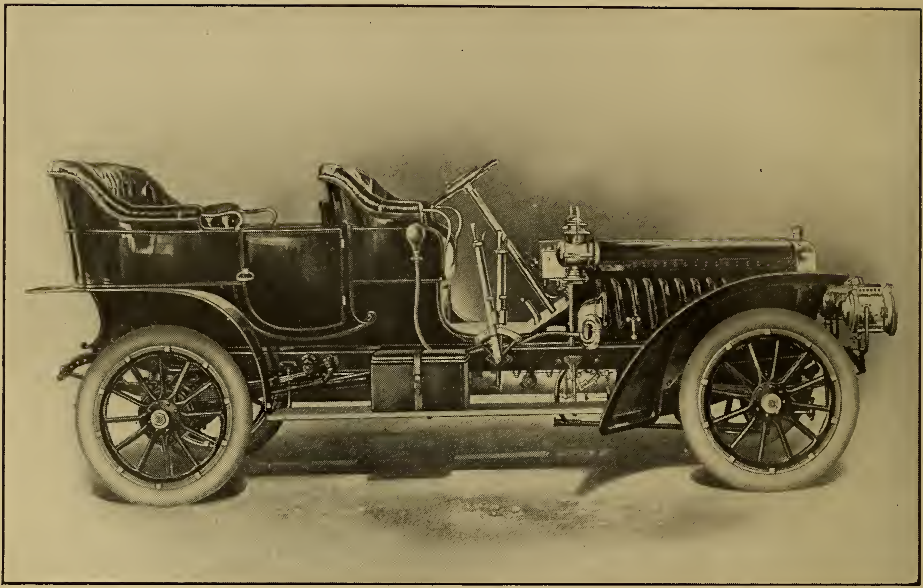


FIG. 16.—STEVENS-DURYEA SIX-CYLINDER TOURING CAR, 35 HORSE-POWER

evident that whatever tends to smooth running will be helpful. The jerky operation of a single cylinder engine is admitted to be bad for the tires. Violent clutching and breaking, rounding corners rapidly, etc., are of course more injurious than any irregularity of stress due simply to the engine; but whatever difference exists in this respect between the "four" and the "six" will favour the latter.

To sum up, it appears that the advantages of six over four cylinders, though most conspicuous for high powers, have serious weight for powers within the range of ordinary touring cars, i. e., cars of from 24 to 30 horse-power. It is not likely that the attractive features of the six-cylinder design will lead to its adoption in piston diameters less than 3½ inches; but from that size upward they may be expected to appeal strongly to the æsthetic sense of the motorist who has outgrown the "speed craze," by exhibiting in a higher degree all the finest characteristics of the best "four," and to do this ultimately at a cost little if any greater than that of the four-cylinder machine.

# POWER TRANSMISSION BY CHAIN

By Edward T- Flax

THE transmission of rotary motion from one shaft to another parallel to it presents a problem of perennial interest and importance to all engineers, and towards its solution many different means have, from time to time, been employed. Roughly speaking, the various methods now used may be said to fall into four classes of drive:

(1) The rope drive;
(2) The belt drive;
(3) The spur-gear drive;
(4) The chain drive.

Of these, the first is the oldest, and the fourth the latest form of power transmission.* A few words on the first three forms of drive will be useful as indicating the considerations which would probably govern the choice of drives. The latest form will be dealt with at greater length.

Rope-driving is, as a rule, used for large powers and great centre distances. Cotton or Manila ropes are generally employed, although wire ropes also give good service and are slightly cheaper. The life of rope drives is very considerable. Tests have shown it to vary from three to six years. A relatively low factor of safety, i. e., one-twenty-fifth of strength at splice, is permissible, which, from the point of view of economy, is an important consideration, and as high speeds as 8,400 feet per minute have been run, although 5,000 feet per minute is the most suitable speed. An efficiency of 83 per cent. can generally be relied on, and the transmitting power of this type of drive can be very easily altered by a change in the number of ropes employed. Generally speaking, ropes form a quiet drive, but not a positive one.

In belt driving, experience has shown that the best speed for economical working is 4,000 to 4,800 feet per minute. Belts give a quiet and relatively cheap form of drive. Their disadvantages are, generally speaking, the loss in efficiency which even slight overloads will occasion and the small horse-power permissible per inch in width, necessitating very wide belts for large powers. Further, belts cannot economically be used on large reductions, as, in order to obtain the necessary adhesion to the small pulley, a considerable tension will be required on the belt, which subjects the bearings to undesirable pressures and very greatly reduces the efficiency. These troubles are most noticeable on short centres, as, on long centres, the weight of the belt is generally relied upon to give the necessary adhesion, the slack side being on top. For power transmission, as met with in ordinary shop practice, however, no means has yet been devised which can compare in economy, of first cost and ease of handling, with belting, especially with regard to unskilled labour.

If the centre distance generally used for belt driving is shorter than that for rope power transmission, spur gearing requires a shorter distance still, and thus can be employed where belting would be impracticable. It is very useful in cases where the power must be transmitted without the pos-

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* The author is aware of a recent German invention in connection with steel ribbon drives manufactured at Charlottenburg by a company formed for that purpose. He considers, however, that these drives have not been on the market, in this country at least, for a sufficient time to be regarded as commercially practical media of power transmission.

sibility of any slip occurring. Except when practically new, spur gearing forms by no means a quiet drive; and while the use of rawhide or paper pinions will mitigate the noise, this is done at the expense of the life. For high speeds or special smoothness of running, the double helical gear is generally used, and this can be run at a speed in excess of any other positive power transmitter, being practically the only possible means of speed reduction on the many high-speed turbines now in use.

We now come to the comparatively recent method of power transmission with which this article especially deals—chain driving.

Chain driving, it may be said at the outset, combines most of the advantages of the older and other methods of power transmission, and yet enables their disadvantages to be largely eliminated. It combines the advantages of spur gearing with the simplicity of belt drives. Some types of driving chains can be used on almost as short centres as gear drives, and yet equally well on extended centre distances, the limit being reached when the weight of the strands and the first cost become excessive. But whatever the centre distances, means for adjustment of centres are required to obtain the best results. The shafts bearing the driver and driven wheel need not be absolutely rigid, and, while the chain drive is perfectly positive, it possesses a certain flexibility.

Chain driving has been practised on a small scale for many years. Its history may be said to fall, broadly speaking, into two parts, the one being the period up to, and the other the period following, the introduction of the so-called "silent form" of chain which Mr. Hans Renold patented in 1894. To him is due, in a large measure, the development of chain driving in England. The general introduction of bicycles brought the possibilities of chain driving very prominently before laymen and engineers alike, and it followed, from the wonderful work the little chain on a bicycle could do, that chains would be applied to many other purposes, such as the driving of machines of all descriptions and the transmission of power from prime movers to machines or line shafts, as well as the propulsion of motor vehicles.

In former times driving chains were regarded as jointed steel bands, with gaps for the teeth to enter; and the wheels were but discs with projections called teeth. Now it is recognized that chain driving is a science governed by definite laws and requiring for satisfactory results very careful and exact calculations as regards the design of chain parts, tooth forms and wheel diameters. It is proposed in this article to deal more particularly with the gradual improvement in modern steel chains, thus omitting any consideration of power transmission by means of detachable-link chains made of malleable iron, which is probably one of the oldest forms of chain, and is still in considerable use for agricultural machines, grinding mills, tunnelling machines, etc., where moderate speeds obtain.

Another form of chain, which does not fall under the heading of a power transmitter in the sense of this article, and which yet forms an interesting link in chain evolution, is the balancing chain. These chains, ordinarily made of Bessemer or Siemens steel, are used for balancing moving parts, such as heavy slides on machine tools, or for lifting and lowering purposes, such as the ring rail in ring-spinning frames.

As we have already said, the bicycle chain may be regarded as the parent of the present power-transmitting chain. In 1879 the drive for the first chain-driven bicycle was supplied to Mr. James Starley, the founder of the cycle industry in England, by Mr. Hans Renold, the originator of the cycle chain. The Renold roller cycle chains are, no doubt, familiar to all our readers. A field which was invaded at a very early

date by chain driving was that of cotton mills, where a series of rollers on carding engines had to be driven. The problem presented here was the transmission of rotary motion from one shaft to another at a very slow speed, and a special type of chain—the card chain—was placed on the market to accomplish this work. We reproduce on this page an illustration of this card chain to show its peculiar tooth form. In action, this chain may be likened to a roller chain with fixed rollers.

In all the early chains the joint consisted of a solid, round pin, free to run in the links. For bicycles, a form was employed in which the centre portion, against which the wheel teeth abutted, consisted of several punched plates built up together, the outside plates joining up these centres into a chain. An improvement was effected by shouldering the rivets, and thus preventing their turning in the outside plates, and a further improvement was made by the introduction of the block by Mr. Hans Renold. This was sawn from a bar drawn to the required section and drilled, giving a greatly improved chain over that in which a series of punchings was used.

All these chains, however, had a sliding action between the wheel teeth and chain; and, to obviate this, the next step was the introduction of the anti-friction roller, at first simply put round the rivet. This, however, caused the whole of the joint-wear to come between the inside pair of plates and the pin; and to reduce this wear a bush was introduced. In this improved roller chain the rivet works inside a bush, the latter being practically solid with the inside plates, while the anti-friction roller, turning loosely on the bush, minimizes the wear resulting from the contact of wheel tooth and chain.


FIG. I.—THE CARD CHAIN; AN EARLY TYPE

By the time, however, that these improvements had made the roller chain more suited for its particular work, chain makers realized that, to meet the widely differing forms of power transmission to which chains could be applied, equally different types of chains, with their proper wheels, would have to be provided. The roller chain, with its improved joint, was gradually relegated to bicycle drives, and, with the general introduction of motor cars, became the standard chain for these vehicles.

While roller chains form a comparatively cheap form of drive, they have admittedly disadvantages resulting from their stretch, owing to wear at the joints, and thus in a short time they become anything but silent in operation. While the roller chain in its various improved forms has, for some time, been practically the standard chain for motor cars, other transmissions are also being successfully effected by its means. Thus, roller chains manufactured by Messrs. Brampton Bros., Ltd., of Birmingham, have been supplied for lifts, conveyors, timing devices, steam-engine governor drives, shaft-winding drums, indicators, weaving looms, etc.; but, as a general rule, the utility of the roller chain in the field of general power transmission is restricted to drives where first cost must be kept low, slow speeds obtain, and silence is not particularly required.

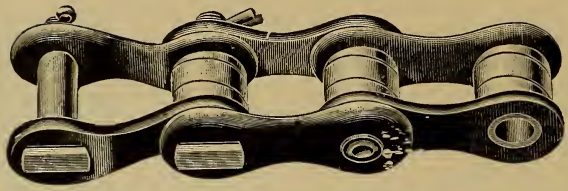


FIG. 2.—THE WORMROLLER CHAIN. COVENTRY CHAIN COMPANY

A considerable improvement, however, has recently been introduced as regards this latter point by the Coventry Chain Company. This firm has pointed out that as in ordinary motor chains the rollers are drilled from the solid bar, they have the natural ringing noise of intact cylinders. The company in question, therefore, introduced, under the name of "Wormroller," a roller in which, although a true cylinder, the natural ring of the metal is destroyed by reason of its laminations. Fig. 2 shows a section of the Coventry Chain Company's "Wormroller" chain, on which the steel strips are visible. An advantage arising from this strip steel construction lies in the fact that the grain of the metal follows the circumference, whereas in the ordinary roller it is transverse. Greater hardening facilities are also claimed for these strips.

Another improvement in roller chain driving, this time in the shape of the wheel tooth, was introduced by Messrs. Hans Renold, who deviated from hitherto existing ideas as to the clearance of the roller in the tooth-gap and advocated a tooth form in which the roller has play in the tooth gap, the base of the space having a larger radius than the roller. With this improvement the disadvantages resulting from the stretch of the chain are reduced, as even with a considerably worn chain none of the rollers are crowded out to the same extent as with the old tooth form, and every roller on the sprocket beds into its tooth gap. The drive thus becomes less noisy, and its action is a continuous and easy rolling. The advantages thus foreshadowed were far more completely realized, however, with the advent of the silent chain. The distinguishing feature of the silent chain gear is that the correct relation is maintained between the pitch of the chain and the virtual pitch of the sprocket teeth.

Silent type chains all belong to the class of inverted tooth chains as opposed to gap chains. Their links are formed of steel plates so shaped that their inwardly-protruding teeth mesh with the teeth of the wheels. This feature, however, would in itself not be sufficient to ensure silence in operation, and was, indeed, embodied in the card-chain illustrated on page 69, its undoubted forerunner. The problem which the makers set themselves to solve was two-fold. First, provision had to be made for counteracting the unavoidable lengthening of the chain through wear; and, sec-

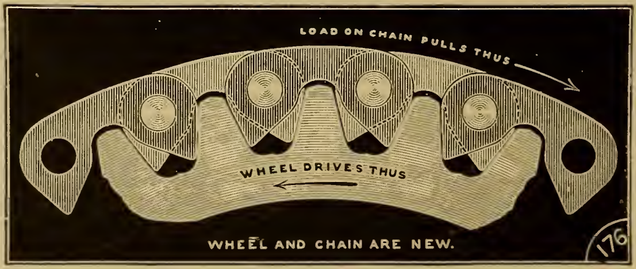



FIG. 3.—RENOLD SILENT CHAIN AND WHEEL WHEN NEW

ondly, means had to be found to ensure that the inverted chain tooth, when coming into contact with the wheel tooth, was subject to no sliding action. The latter question was solved by the design of the chain tooth. Figs. 3 and 4 show a section of a Renold silent chain when new and when the chain has worn. As the chain wears, it rises automatically on the sprocket teeth, thus ensuring that a proper engagement takes place between chain and wheel teeth, and that the load to be transmitted is evenly distributed over all teeth in contact, until the chain finally reaches the top of the wheel teeth and is worn out. The adaptation of the chain to the required pitch diameter has been the secret of the great quietness obtained by this type, rightly called "silent," and the flat tooth engagement is the basis of construction of all compensating "silent chains." Messrs. Hans Renold, from building chains with soft rivets and soft plates, soon progressed to case-hard rivets, and, later on, much improved the wearing qualities by introducing sawn blocks of steel drawn to the correct section, and having small cuts in the inside of the teeth, as shown in Fig. 5. When the chain was in motion, the centrifugal force tended to throw the oil into these grooves, by means of which it reached the rivet, being further distributed along the bearing surface by means of double spirals cut on the rivet in opposite directions. The pins, and also the blocks, were all case-hardened, making a very fine example of an exact and finely-finished piece of mechanism.

While, however, makers were thus successful in the direction of counteracting the effects of the lengthening of pitch due to wear at the joints, no pains were lost to overcome the source of the trouble.

It follows that special attention was centred on the construction of the joint itself. This led to the radical deviation, by the Morse Chain Company, then of Trumansburg, N. Y., from the accepted standard of a single-pin joint, and has divided this whole subject of practical chain-driving into two sections, namely, silent chains, of which the joint is built with a solid pin, and those in which the joint consists of a two-part pin.

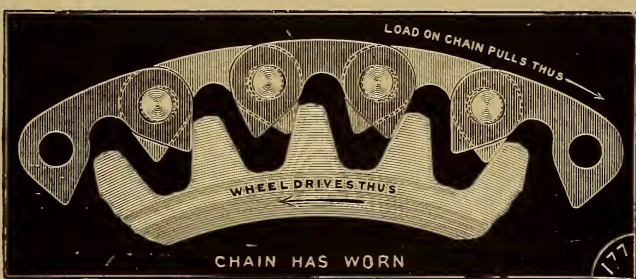



FIG. 4.—RENOLD SILENT CHAIN AND WHEEL WHEN WORN

The leading exponents of the former type of silent chain in England are Messrs. Hans Renold, Ltd., Manchester, while the latter form of chain is controlled by the Westinghouse Brake Company, Ltd., London, working under the Morse patents. The two-part pin undoubtedly forms a very important step in the history of chain construction, as, from this feature, are derived a number of improvements affecting the efficiency, silence and life of chain drives.

The theory underlying the Morse two-part joint is the same as that governing ball bearings. The Morse joint consists of two hardened steel surfaces, the one bearing on its flat face the knife edge of the other. This method is illustrated in Fig. 6. The makers claim that no sliding

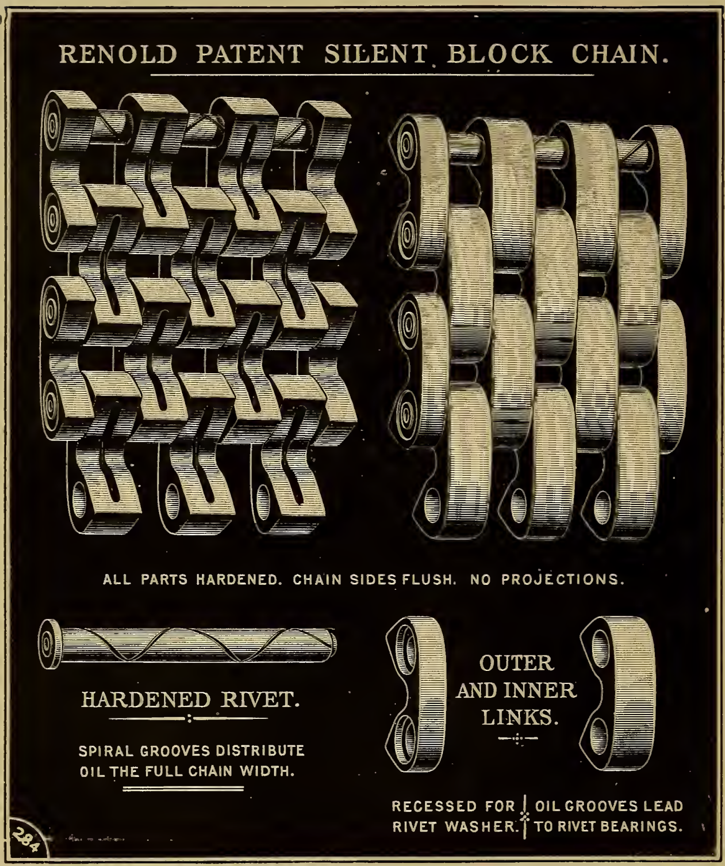



FIG. 5.—DETAILS OF THE RENOLD SILENT CHAIN

friction whatever can take place at the contact point, the knife edge simply rocking to and fro on the "seat pin" as the joint passes on and off the sprockets. Owing to the seat pin being practically solid with alternate links in the chain and the rocker pin with the adjacent links, no relative movement can take place between the links and the backs of the pins. This, therefore, evidently constitutes the nearest approach to the elimination of wear at the joint as yet secured.

Fig. 7 shows a section of the Morse "silent" rocker-joint chain (as the makers call it), one outside link being cut away so as to show the action of the seat and rocker pins. The absence of wear at the joint results in only the minimum amount of lubrication being required, from which it would follow that this form of chain can be run at speeds which would, owing to centrifugal action, throw off all lubricants. As regards the efficiency of this new chain, the makers place it at 99 per cent. when new. It would, therefore, appear to be one of the most economical forms of power transmission known. A further undoubted advantage exists in the extended bearing surfaces afforded by this rocker joint, as the seat pin extends the full inside width of the chain, thus giving a corresponding bearing surface. The action of the joint is such that the knife edge bears against the seat-pin only while the chain is actually on the wheel; but the strands between the sprockets—i. e., the parts under

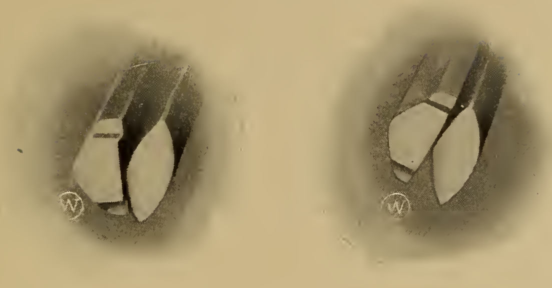


FIG. 6.—THE MORSE ROCKER JOINT

tension—have the flat side of the rocker pins resting against the face of the seat-pins, which gives not only an extended but also a broad bearing surface under the load.

In the Renold solid-pin chain the benefit of this extended and increased bearing surface has been obtained by a striking improvement, to appreciate the nature of which it must be borne in mind that, with former Renold silent chains, the plates bore alternately on the studs, and that the wearing surface on each side was only half the stud length. The bearings were broken up into as many parts as there were plates, and lubricating oil was, therefore, soon forced

FIG. 7.—SECTION OF MORSE SILENT ROCKER-JOINT CHAIN

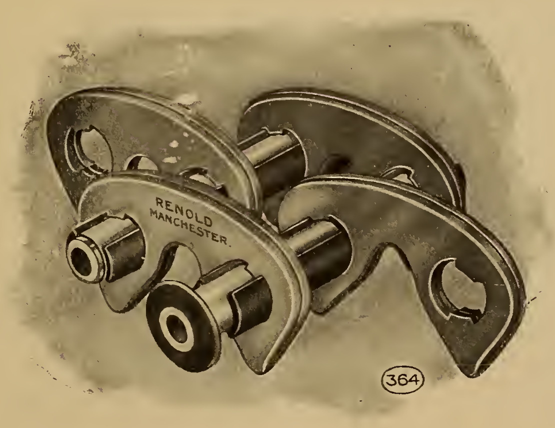



FIG. 8.—THE RENOLD SOLID-PIN CHAIN

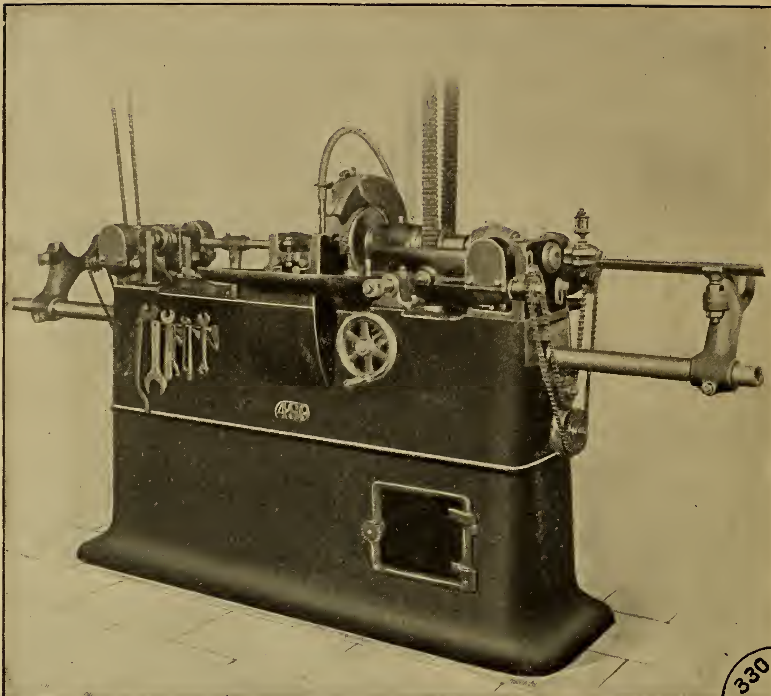



FIG. 9.—RENOLD CHAINS DRIVING GRINDING MACHINE

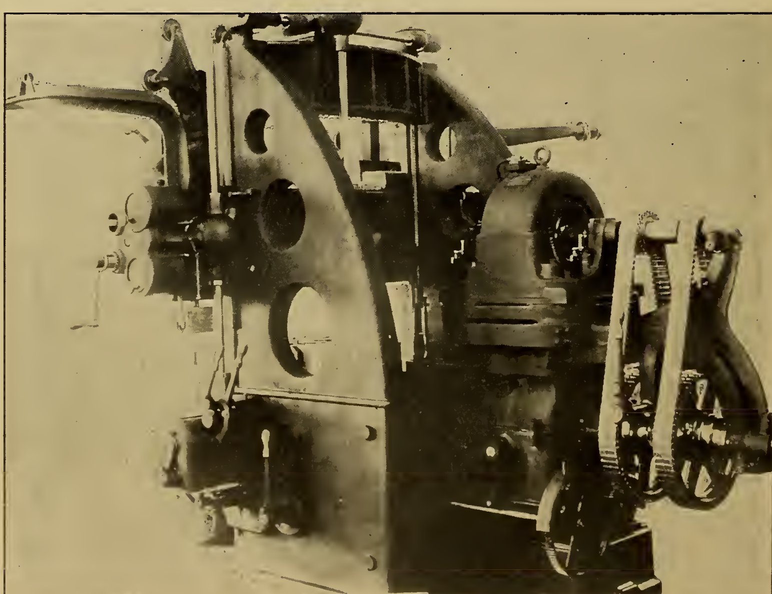


FIG. 10.—MORSE CHAINS AND ELECTRIC MOTOR DRIVE ON BORING MILL

FIG. 11.—TWO 500 HORSE-POWER MORSE CHAIN TRANSMISSIONS. WESTING HOUSE BRAKECOMPANY

out. The improvement referred to consists in the introduction of bushings, fixed in the plates and bearing on the studs. These bushings extend the full width of the chain, thus giving a corresponding bearing surface, which is, therefore, practically doubled, as compared with the bearing surface of the former type. The bearings of the new chain retard the lubricating oil; they are hardened, and they bear on hardened studs. This will best be seen from Fig. 8.

Both the Morse and the Renold types of silent chains have found a very wide application in Europe and America. Fig. 9 shows an excellent application of Renold chains of the two distinctive classes (roller and silent) to the same machine. The drives from the counter to the main feed shaft and from the latter to the feed drives are effected by roller chains $\frac{3}{4}$-inch and $\frac{5}{8}$-inch pitch, respectively, while a $\frac{5}{8}$-inch pitch, 2-inch wide silent chain drives the emery wheel.

Fig. 10 represents an ingenious double drive by means of two Morse silent chains from a motor to a Gisholt boring mill. As before mentioned, the Westinghouse Brake Company state that, as the Morse chain does not require much lubrication at the joints, it can be run at considerably higher speeds than chains of the single-pin construction, and Morse drives have been installed working satisfactorily at chain speeds of 2,100 feet per minute.

Both the Renold and Morse type of silent chain are employed for every conceivable type of power transmission where speeds are fairly high. With the Morse chain drive the greatest reduction which the makers will ordinarily supply is 1:10, while Messrs. Hans Renold do not advise a greater ratio than 1:6. One of the biggest power transmissions ever at-

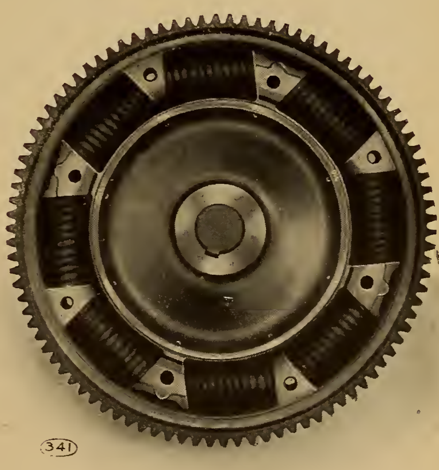


FIG. 12.—THE RENOLD SPRING CHAIN WHEEL

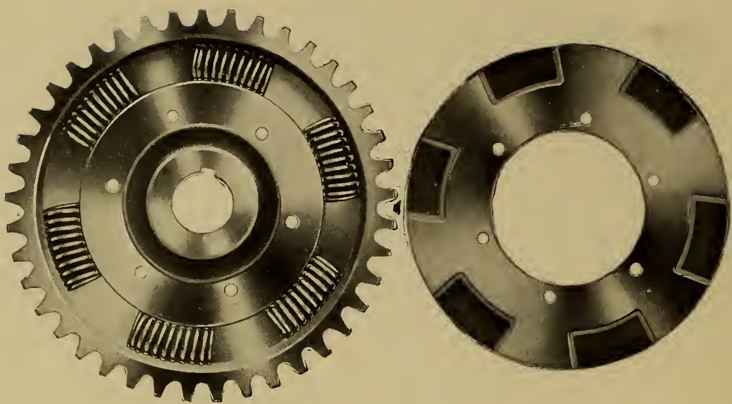


FIG. 13.—THE WESTINGHOUSE-MORSE SPRING CHAIN WHEEL

tempted by chain has recently been supplied by the Westinghouse Brake Company. This consists of two 500 horse-power drives, each drive being composed of a driver and driving wheel, $37\frac{3}{4}$ inches diameter by 22 inches face, and two chains, each 10 inches wide, running side by side over the wheels. An illustration of these colossal drives is given in Fig. 11.

Among the uses to which silent chains are applied, none is more punishing than the driving or pumping or similar machinery in which the chain is subject to intermittent shocks. Messrs. Hans Renold, Ltd., have very adequately provided for this severe service by the introduction of their spring wheel, shown in Fig. 12. This innovation has opened up to chain driving a field which hitherto was inaccessible, owing to the inability of even the most carefully designed chain to withstand, for any length of time, the constant jerks and backlash.

An illustration of the Westinghouse Brake Company's Morse spring wheel, slightly differing in construction, is given in Fig. 13. As became the sponsors of chain power transmission, Messrs. Hans Renold have set the example in shop driving by so equipping their own works. Fig. 14 shows their automatic room, where the line shafts are driven by silent chains and the countershafts by silent or roller chains. An incidental, though obvious, advantage lies in the fact that, while adequate belting would seriously obstruct the light, the chain drives permit it to fall quite freely on the machine.

With the advent of the motor omnibus and the imperative demand for silence in its operation, a great field was opened up for silent chain transmission, of which the leading makers have taken full advantage. There can be little doubt that the silent form of chain will, sooner or later, also capture pleasure cars.

What appears to be the latest improvement in vehicle-driving chains is to the credit of the Westinghouse Brake Company, Ltd., who have just put out a Morse chain showing a further improvement, while retaining the rocker or two-part joint. The tendency to stretch has been largely decreased by the increase in the section of the joint pins used. This increase amounts to about 60 per cent., thus yielding a larger bearing surface and decreasing the crushing action. The disadvantage attending this new feature appears to be the resultant increase in the weight of the chain.

As the author of this brief sketch has attempted to show, such remarkable improvements have been made in chain driving that it has now been firmly installed as a form of power transmission presenting many advan-

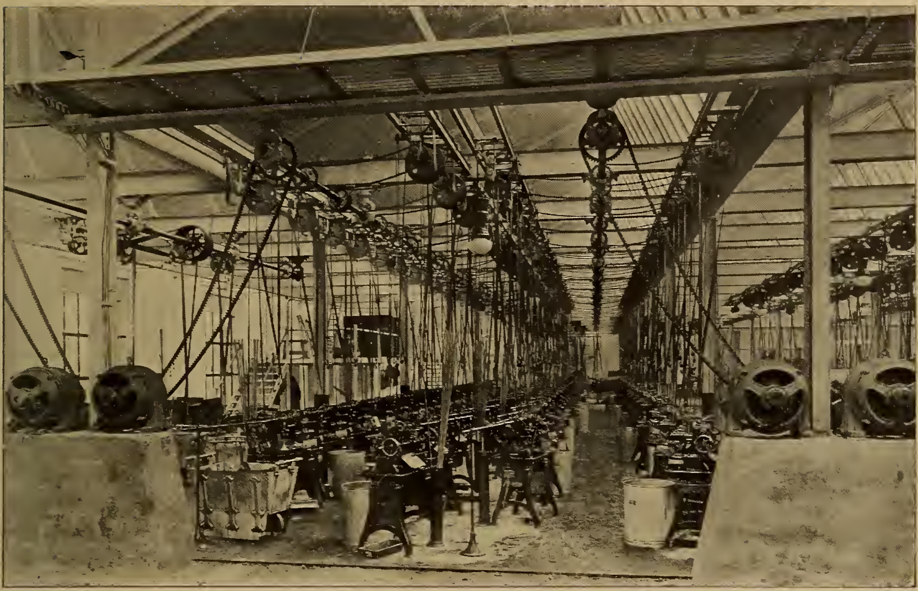


FIG. 14.—INSTALLATION OF CHAIN DRIVING IN THE AUTOMATIC ROOM OF HANS RENOLD & CO., MANCHESTER

tages unobtainable with other methods. But the great problem facing manufacturers still remains: How to increase the life of chains and wheels, and how to eliminate still further lengthening at the joint.

Having regard, however, to what has already been done, there is every reason to anticipate that during the next few years we shall be indebted to our leading manufacturers for even greater advances in the quest after the ideal chain.

The writer wishes to express his indebtedness to Messrs. Hans Renold, Ltd., Manchester; the Westinghouse Brake Company, Ltd., London; the Coventry Chain Company, Ltd., Coventry, and Messrs. Brampton Bros., Ltd., Birmingham, for information and illustrations relating to their respective manufactures.

# THE PURCHASE OF COAL ON A SCIENTIFIC BASIS

By John B. C. Kershaw

FUEL-USERS, as a class, are not scientific in their manner of purchasing coal, and the methods which satisfied the manufacturers of the last generation are still in general use to-day. No other raw material of equal importance to the economic conduct of our industries is purchased with such an absence of effective means for checking the quality of the supplies. When one considers that the average consumption of fuel in the United Kingdom is 180,000,000 tons per year, valued at £81,000,000, and that five-sixths of this total, or 150,000,000 tons, are consumed in the manufacturing industries of the country, the need for some more scientific method of purchase and control should be manifest.

The usual method of selecting coal is also open to criticism, while the means taken to ensure that deliveries of the selected coal, often amounting to thousands of tons, shall be up to the standard of the trial wagon, or wagons, are ludicrously inefficient and inadequate.

This condemnation of the methods at present in general use will, no doubt, be controverted by many interested either as sellers or buyers in the use of coal in our manufacturing industries, and, therefore, a more detailed statement of the case against the present methods is desirable.

First, as regards choice of fuel. The method in general use at the present time is to order sample wagons from several different collieries or large coal merchants and to burn each wagon-load of fuel under the boilers or furnaces, with observation of the results. The observation of the results obtained may be crude or elaborate, but in either case the final results obtained by such a method of testing are inaccurate and untrustworthy.

In the first place, the sample wagons of coal may have been exposed to very different conditions as regards weather during their transit from the colliery to the works, while washed fuels are naturally wet when leaving the colliery; therefore, the moisture contents of the fuel, when burned, may vary from 1 up to 8 or 10 per cent. The effect of the comparative wetness or dryness of the fuel charged into the furnace upon the working results will be large; but it is rarely allowed for in this kind of practical test, and the better fuel may yield the worse results, owing to its accidental delivery in a wet condition. Secondly, every kind of fuel requires certain conditions to be fulfilled as regards method of firing, air supply and draught, etc., in order to obtain from it the best possible results. This adaptation of the furnace and draught to the fuel burnt is seldom made by engineers when in charge of such tests. All the fuels are burnt, as far as possible, under the same conditions, and thus a handicap is placed upon the fuels which require conditions differing from those usually obtaining in the boiler or furnace with which the trials are made. As regards steam-raising tests, in cases where a large number of comparative trials are being carried out with the same boiler, the changes in weather and increasing thickness of scale on the boiler are bound to affect the results. Other things being equal, the fuel first tested, with the boiler in the

cleanest state and with a dry atmosphere, will show better results than the fuel tested on a damp day towards the end of the testing period with the boiler badly scaled. Finally, the skill and reliability of the firemen have great influence upon the results, and in a long series of tests it is almost impossible to keep the same men continuously on the work, or to be quite certain that they are not being "got at" by the agents of the colliery company. Firemen also have their preferences in the matter of fuel, and will naturally desire to have the coal selected which gives them least trouble in stoking and cleaning their fires. There is, consequently, no guarantee—even when the external conditions are all favourable to the accuracy of the tests—that the comparative trials of the various fuels will place the buyer in a position to decide which yields the largest amount of heat per ton or is the most effective steam-raiser. The only information obtained is which fuel is most favoured by the stokers or engineer in charge of the boilers.

The value of these trials is, in fact, enormously less than is imagined by manufacturers and engineers. If any reader of these criticisms is disposed to still doubt the truth of this statement, let him carry out half-a-dozen steam-raising tests with the same fuel under the conditions which would obtain if different wagons of fuel were being tested he will find, to his surprise, that the results obtained vary within wide limits, and that the claim of practical steam-raising trials to be considered accurate or reliable is based chiefly upon the prejudice in their favour and is largely imaginary in character.

Turning now from the methods used for selecting a fuel to those used for checking the quality of the deliveries under the contract, we find that these are hopelessly inadequate.

The purchaser having selected a fuel by the method described above, inserts a clause in the contract specifying that the deliveries shall be from the same colliery and from the same seam as the trial wagon, and then assumes that the matter is settled and that no variation from the quality of the trial wagon is possible.

A visit to the head of the pit from which he is obtaining his fuel, or, better still, a visit to the workings underground, would show the futility of this supposed check upon deliveries. All coal seams lie between layers of shale or non-combustible matter, and in getting the coal a considerable amount of this shale or dirt is brought to bank with the fuel. Hand-picking is employed to remove this impurity from the best house coal, and washing for the higher-priced smalls and slack used in the manufacturing industries, while the low-priced fuel is sold as it comes from the pit, without any cleaning whatever. The amount of shale or dirt left in the fuel varies, therefore, with the thoroughness of the picking or washing operation. Thus fuel from the pit, without any cleaning may vary from 5 to 15 per cent. in its ash contents, for if the work be pushed, or the supervision be faulty, more shale and dirt pass into the wagons with the fuel. As a check upon the qualitv of supplies, the usual contract clause is, consequently, absolutely valueless, and it is surprising that fuel-users, as a class, have for so long pinned their faith to it.

As before, the writer recommends any fuel-user who doubts the accuracy of this criticism to put it to a practical test. Let him visit the colliery from which he is obtaining fuel supplies without revealing his identity, and let him study the actual mining, screening, picking and washing operations. In nine cases out of ten he will return converted to the writer's opinion.

What, then, is offered as a substitute for the usual methods of selecting and controlling fuel supplies described and criticized above? Simply the methods which are used for testing and controlling the supplies of

other raw materials, namely, chemical and laboratory tests carried out by chemists who have had experience in this class of work.

Coal is a mixture of combustible and incombustible matter. By comparatively simple tests the amount of the latter can be determined and the results used to ascertain the amount of real combustible present in the fuel.

The following scheme of analysis shows the tests that are required to ascertain approximately the quality of the fuel:

| | | |
|---|---|---|
| Coal.... | Combustible matter...... | Sulphur.<br>Hydrocarbon Gases.<br>Fixed Carbon. |
| | Incombustible matter..... | Ash.<br>Moisture. |

By heating the sample of fuel two hours at 230 degrees F., all the moisture is driven off; bv raising the dried sample to a red heat in a closed crucible, the hydrocarbon gases and sulphur are expelled, and by continued heating of the residue in an open crucible or dish, with access of air, the solid carbon is burned off and only the ash is left behind.

A test of this kind, carried out with a reliable sample of the fuel, can be made in three hours, and yields results far more trustworthy than the expensive and lengthy steam-raising trial already described and condemned.

From the results of this test the calorific or heat value of the fuel can be calculated by the use of a well-known formula. A further check with one of the more accurate forms of fuel calorimeter. In this apparatus, a known weight of the fuel is burned completely in a vessel immersed in a known weight of water, and from the rise in temperature of the latter the heat produced by the combustion of the fuel is ascertained.

The accuracy of this method of testing fuel is proved by the fact that close agreement is found between successive tests made upon the same sample of fuel by a chemist skilled in the use of the apparatus. The calorific value, as calculated from the result of the approximate analysis, is also generally found to be in agreement with the calorific value as directly observed in the calorimeter test.

With these results before the purchaser, it is a comparatively simple matter to determine which is the best or cheapest of a number of different fuels. Having selected a fuel, the results of the test of the sample wagon can be inserted in the contract as a standard for future deliveries. By taking frequent samples of the coal delivered and from these preparing average samples, which are tested daily or weekly, an accurate check is provided over the quality of the fuel delivered under the contract, and excess of moisture or ash, with the resultant deficiencies in calorific value, is at once detected.

As a practical example of the application of this method of coal-purchase on scientific lines, the following may be given:

ACTUAL TEST-RESULTS OF SIX BITUMINOUS COALS, WITH PRICE PER TON DELIVERED IN BUNKERS AT THE CONSUMER'S WORKS

| Description of Fuel. | $H_2O$ Per Cent. | Ash, Per Cent. | Volatile Matter, Per Cent. | Fixed Carbon, Per Cent. | Calorific Value. | | Price per ton. *s. d.* |
|---|---|---|---|---|---|---|---|
| | | | | | Observed. | Calculated. | |
| Marchay rough slack..................... | 7.8 | 3.0 | 35.3H | 61.65 | 14,965 | 14,785 | 8.8 |
| Digby bright peas........................ | 10.4 | 6.5 | 36.5 | 57.0 | 14,283 | 13,865 | 7.9 |
| Shiply peas................................ | 7.7 | 7.7 | 34.0 | 58.2 | 14,203 | 13,975 | 7.11 |
| Manners peas.............................. | 7.4 | 10.7 | 33.6 | 55.6 | 13,815 | 13,482 | 7.5 |
| Wigan and Skelmersdale.................. | 6.7 | 16.5 | 28.8 | 54.7 | 13,041 | 12,965 | 8.4 |
| Wigan...................................... | 4.9 | 16.8 | 30.1 | 53.0 | 12,929 | 12,760 | 8.3 |

upon the value of the fuel can be obtained by a calorimeter test, made

These results indicate at once that the Marchay rough slack is the best

of the six fuels, since the ash test is very low and the calorimeter test is in close agreement with the calorific value as calculated from the other results. A low ash test is of considerable importance, for not only does it indicate a larger proportion of combustible per 100 tons of fuel, but the costs for handling and carting clinker and ash are largely reduced. As compared with the fuels which are placed fifth and sixth in the list, the cost of removing ash from the No. 1 fuel would only be one-sixth. Further, it must be remembered that ash tends to prevent complete combustion of the fuel, and that the higher the percentage of ash, the larger will be the proportion of combustible matter which escapes combustion and is thrown away with the clinker and ashes.

The decision as to the choice of a fuel in this case rested, however, not merely upon low ash contents and high calorific value, but upon cheapness; that is, the price had to be considered in relation to the heat value of the fuel. The British thermal units obtained per penny of outlay were, therefore, worked out, the mean of the two values given in the last table being taken, multiplied by 2,240 to give the British thermal units in one ton of fuel, and divided by the price per ton in pence. The figures in Column II. were obtained by deducting a number of British thermal units equivalent to the percentage of moisture from the results in Column I.

BRITISH THERMAL UNITS PER PENNY OF COST OF SIX BITUMINOUS FUELS

| | Col. I. On Dry Fuel. | Col. II. On Fuel as Delivered in Bunkers. |
|---|---|---|
| Manners peas | 343.525 | 318,005 |
| Digby bright peas | 338,987 | 303,733 |
| Shiply peas | 332,204 | 306,625 |
| Marchay rough slack | 320,384 | 295,395 |
| Wigan and Skelmersdale | 291,267 | 271,753 |
| Wigan | 290,612 | 276,373 |

The fuel which cost the lowest was, therefore, proved to be the most valuable when compared on this basis, and the coal with the lowest ash contents and highest calorific value was relegated to the fourth position on the list.

In the final decision with regard to these coals consideration was, however, given to the moisture and ash contents, and the Shiply Peas testing—7.7 per cent. each of moisture and ash, and yielding 306,625 British thermal units per penny of cost as delivered—was secured.

Having made the selection of fuel in this manner, the more important of these figures can be included in the contract, the clauses regulating the quality and price being worded as follows:

"CLAUSES FROM FORM OF FUEL CONTRACT USED IN CHICAGO BY THE FUEL ENGINEERING CO. OF UNITED STATES OF AMERICA*

"I. The consumer agrees to purchase from the company all of the coal required for consumption on the said premises during the term of this contract, except as set forth in Paragraph III. below, and to pay the company for each ton of 2,240 pounds avoirdupois of coal, delivered and accepted in accordance with all of the terms of this contract, at the following contract rate per ton, for coal of each respective contract

| Kind of Coal | Contract Rate per Ton. | | Contract Guarantee. |
|---|---|---|---|
| | £ s. d. | Equal to | Net B. T. U. for one penny. |
| | £ s. d. | Equal to | Net B. T. U. for one penny. |
| | £ s. d. | Equal to | Net B. T. U. for one penny. |

* In this abstract of the form of the contract of the Fuel Engineering Company the weights and money values have been changed to suit English requirements. In the original form the only difference is that the ton is specified as containing 2,000 pounds, and that the contract guarantee specifies the number of British thermal units for one cent; the contract rate per ton being also expressed in cents. A valuable discussion of this subject from the American point of view will be found in Bulletin No. 339 of the United States Geological Survey, entitled: "The Purchase of Coal Under Government and Commercial Specifications on the Basis of its Heating Value, with Analyses of Coal Delivered Under Government Contracts." by D. T. Randall.—Editor.

grade, at which rates the company will deliver the following respective numbers of British thermal units for one penny (the contract guarantee): The net British thermal units for one penny are, in each case, determined as follows: Multiply the number of British thermal units per pound of dry coal by the percentage of moisture (expressed in decimals), subtract the product so found from the total number of British thermal units per pound of dry coal, multiply the remainder by 2,240, and divide this product by the contract rate per ton (expressed in pence) plus one-fourth of the ash percentage (expressed as pence).

"II. Should any coal delivered hereunder contain more than the percentage of ash or moisture, or fewer than the number of British thermal units per pound, dry, allowed under Paragraph IV. hereof, the consumer may, at its option, either accept or reject the same.

"III. All coal accepted hereunder shall be paid for monthly at a price per ton determined by taking the average of the delivered values obtained from the analyses of all the samples taken during that month, the said delivered value in each case being obtained as follows: Multiply the number of British thermal units delivered per pound of dry coal by the percentage of moisture delivered (expressed in decimals); subtract the product so found from the total number of British thermal units delivered per pound of dry coal; multiply the remainder by 2,240, and divide this product by the contract guarantee. From this quotient (expressed in pence) subtract one-fourth of the ash percentage, delivered (expressed as pence).

"IV. For the purpose of determining the quality of coal delivered hereunder, it is agreed that the consumer shall cause samples to be collected and analyzed by the Fuel Engineering Company at the consumer's expense, as follows: A fair average sample of the coal delivered hereunder shall be collected not less than once each week. If only one such sample be collected each week, each such sample shall be analyzed. If more than one sample be collected per week, average samples shall be made, which shall include all samples collected, and such average samples shall be analyzed. The results of all analyses made, together with the delivered values determined by such analyses, shall be reported promptly to the company. The company may have a representative present at the time of selecting of any or all samples as above. When requested by the company, such sample shall be divided into three parts, one given to the consumer, one to the company, and the third shall be sealed in the presence of the representatives of both and kept by the consumer. If the company so requests in writing, within five days after receipt of the report of the consumer's analysis, as provided above, the third sealed part of the sample shall be delivered to a chemist of standing, to be mutually agreed upon, and analyzed at the expense of the company. This analysis shall then be final and binding."

It may be urged that no colliery company in Great Britain would bind itself to sell fuel under such an agreement as that outlined above. The answer to this objection is, that the form of agreement reprinted above has been used by the Fuel Engineering Company of Chicago for many of its clients with marked success, and that similar agreements have already been made by some fuel-users in this country. Colliery proprietors will, in those cases in which competition exists, be obliged to adapt themselves to the changed conditions as regards the sale of coal; and if they find they can only sell their fuel to large consumers on a heat-value basis, they will do it, rather than lose such a customer. Further, the agreement cuts both ways. If the fuel delivered is below the contract heat value, the price is correspondingly reduced; but

if the fuel delivered is better in quality than the contract guarantee, the price is automatically increased. Thus the colliery company, or proprietor, has a direct incentive to supply good fuel under the contract, and in many cases, no doubt, the result would be that a higher average price would be obtained for the fuel deliverers than under the present system.

The colliery companies and proprietors, in fact, when they had once become accustomed to the new method of selling their fuel, would be heartily in favour of it.

A final objection remains to be dealt with. Who is to undertake the sampling and testing of the fuel under this form of contract? Both the buyer and the seller are interested parties, and samples taken by the agents of either would be disputed by the other party to the contract. The difficulty has been overcome in America by the formation of an independent organization known as the Fuel Engineering Company of Chicago. This company has founded a sampling service in a number of towns around Chicago, and it undertakes the sampling and testing of coal with special reference to its supply under contract guarantees. The results are sent to both the consumer and the supply company. A very large number of firms in Chicago have put the control of their fuel supplies into the hands of this independent company, and the writer has before him a printed return, published in March, 1907, giving over 250 tests of the fuel samples collected in that month. These monthly reports of the tests made are circulated among all the clients of the Fuel Engineering Company, and, by comparison of the results, much information is gained of value to the fuel consumer.

A quotation from an article written by Mr. E. H. Taylor, one of the officers of this company, may close this contribution to the discussion of the subject:

"This method of buying coal is employed by many of the office buildings, public institutions and manufacturing companies in Chicago, and has been thoroughly tested and found to be admirably adapted to the purpose. Under this system the consumer pays for the amount of heat actually received instead of for so many tons of coal, regardless of the quantity of heat it contains.

"This system is well liked by the honest coal dealer, as it protects him from unfair competition with dealers who might otherwise cut the price on good coal, expecting to substitute occasionally an inferior grade of coal without being detected."

# MODERN HYDRAULIC MACHINERY

By Carl Wigtel

## II.—HYDRAULIC JACKS AND PRESSES

IN a previous article on modern hydraulic machinery, pumps, accumulators and distributing mains for hydraulic plants were discussed.

Hydraulic presses that are operated from accumulators are generally of the stationary type, and in most cases they are machines of large size and of great capacity.

Before going into the style of presses that are incidental to large hydraulic-pressure plants, it may not be out of place to mention a few hydraulic tools of the portable variety, such tools as are used by railroads, contractors, in machine shops and for a variety of other purposes.

Among the portable tools, the hydraulic jack is one of the most important. Hydraulic jacks are used for a number of purposes in nearly all engineering undertakings of the present day, and there is hardly a field in which the hydraulic jack does not play an important part. While jacks are designed with but one purpose in view, that of exerting a force either in lifting, pushing or pulling, there are a great number of styles and varieties to meet the different conditions. As an illustration we may mention that one firm of jack makers advertises as many sizes and varieties of jacks as a well-known firm of pickle makers advertises the varieties of their product.

The ordinary hydraulic jack consists of a hydraulic cylinder, a cistern for holding the pressure fluid and a hand pump for generating the pressure. Some suitable valve mechanism is also provided in order to release the pressure fluid when it is desired to let the jack descend.

A number of different designs of hydraulic jacks are shown in accompanying illustrations. These are self-contained jacks with the cylinder, pump and cistern, all connected to make a self-contained machine.

Another form of independent pump jack is that in which the jack proper is connected by a flexible copper pipe to a separate hand pump. The latter style of jacks is often adaptable where self-contained jacks cannot be used to a good advantage; for instance, in places where the jack has to be mounted in such a position that the pump handle of the ordinary jack could not be operated with ease.

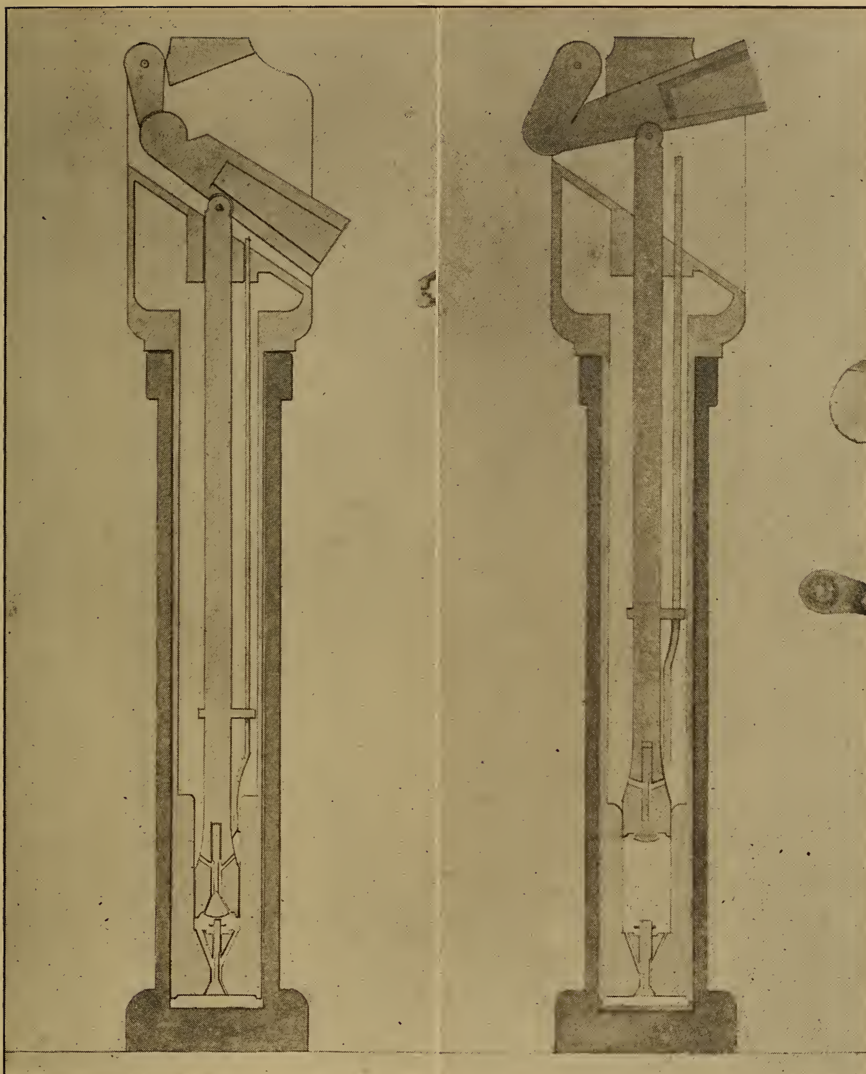
The telescopic car jack is also worthy of mention as a suitable tool where a long reach is required for a minimum height overall when the jack plunger is down in lowest position.

Special jacks are made for removing motors from electric cars, these including a street-car motor lift, and a telescopic motor-lift jack for the same purpose.

The Vreeland transfer jack, now in use in most round houses in the United States, may also be mentioned as a suitable contrivance for removing and replacing drivers and trucks on locomotives.

Hydraulic jacks are much used for lifting tracks and for wrecking purposes. In erecting large buildings and bridges and for moving heavy weights, the hydraulic jack also plays a prominent part.

Another important field for the hydraulic jack is the building of tunnels through sand or clay. A steel cylinder of the same diameter as the outside diameter of the lining or



THE ORIGINAL HYDRAULIC JACK. INVENTED BY RICHARD DUDGEON, 1851

brickwork of the tunnel is forced forward by a number of jacks located inside the shell of the shield, and the rams of these jacks push the shield forward against the finished lining or brickwork of the tunnel. The sand or clay is removed through suitable openings in the diaphragm of the shield and new liners are put in place when the shield has been forced forward a few feet. The shield cylinders are sometimes operated by hand pumps, but for large shields, where a great number of heavy jacks are required, a steam or electrical-driven pump is generally used for generating the pressure. Such shields are often furnished with an hydraulic erector for hoisting the lining segments into place.

Two views of a 17-foot tunnel shield, with erector mounted on

shield, are shown in accompanying illustrations. This shield has sixteen jacks, each of 125 tons capacity.

Similar hydraulic jacks are sometimes used for sinking vertical shafts in mines, and hydraulic jacks are also used for pulling up pipes that have been sunk for oil or water wells.

Hydraulic jacks are also used for timber logging machines, for pulling out roots of trees and for other purposes.

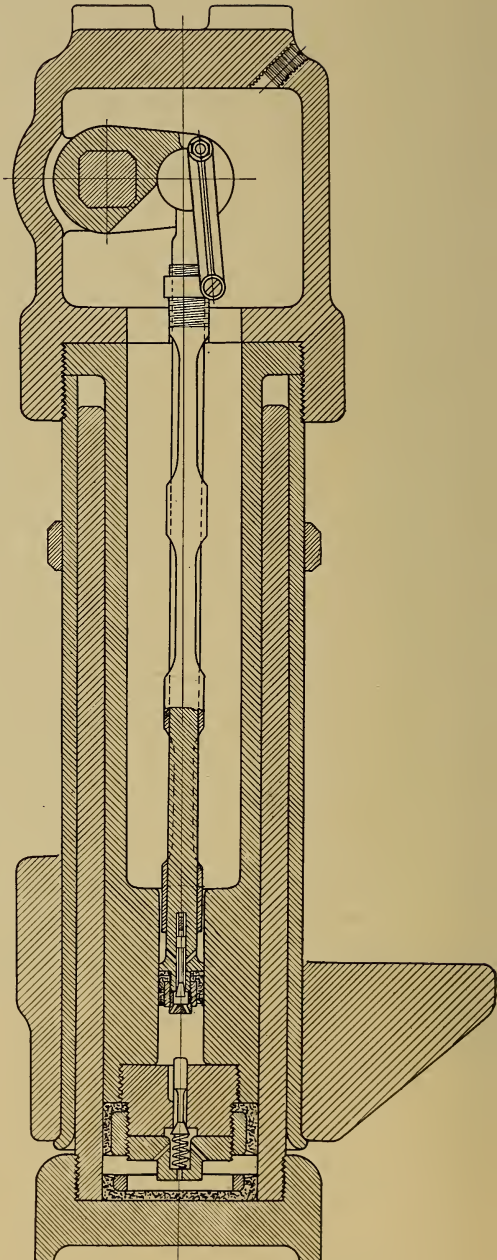
It is well to bear in mind that hydraulic jacks, in order to be effective for lifting or pushing, must have a good foundation to push against, as the force against the foundation is equal to the load that is to be lifted. If a jack, when placed under a load of, say, 50 to 75 tons, is supported by a weak foundation, the foundation will be depressed and the load will not be lifted.

Among the illustrations are shown a number of portable tools, such as punches, benders, straighteners, riveters, etc.

These tools may exert as great a force as most hydraulic jacks, but in all these latter tools just mentioned the force is taken up by the frame of the machine, so that all that the foundation has to stand is only the weight of the machine, which, in most portable tools, only amounts to a few hundred pounds.

The writer recollects an incident when a shear of 75 tons capacity was to be tested in a certain store in New York City. The shear was ready for operation when the owner of the building happened to enter, and upon learning that the shear exerted a force of 75 tons, he got very much excited and declared his floors were not built for any such pressure, and it took some time to convince the man that the great pressure exerted in this particular tool was taken up by the frame of the machine, and that all his floor had to hold was the weight of the machine.

Hydraulic tools are used for a number of operations where a great force is required for punching, bend-



THE MODERN HYDRAULIC JACK

HYDRAULIC CLAW JACK

ing or shearing. Such tools are generally operated by hand, and the arrangement of the pump and press plunger is, with few exceptions, the same in all of them.

The ram or press plunger can be moved rapidly up and down by a rack and pinion mechanism. When the ram is pushed out by the rack, the cylinder is filled automatically, and when the resistance on the pinion handle becomes too great to move the ram, the pump handle is resorted to for the final pressure. The pump is located inside the vertical head or reservoir, projecting upward from the cylinder. An additional movement of the pump handle will release the pressure and the ram can then be moved back to its original position by the pinion lever.

Portable tools of this class are built for punching steel plates or rails, for straightening shafts, bending iron beams, shearing steel bars or wire, and for riveting copper bonds in rails, etc.

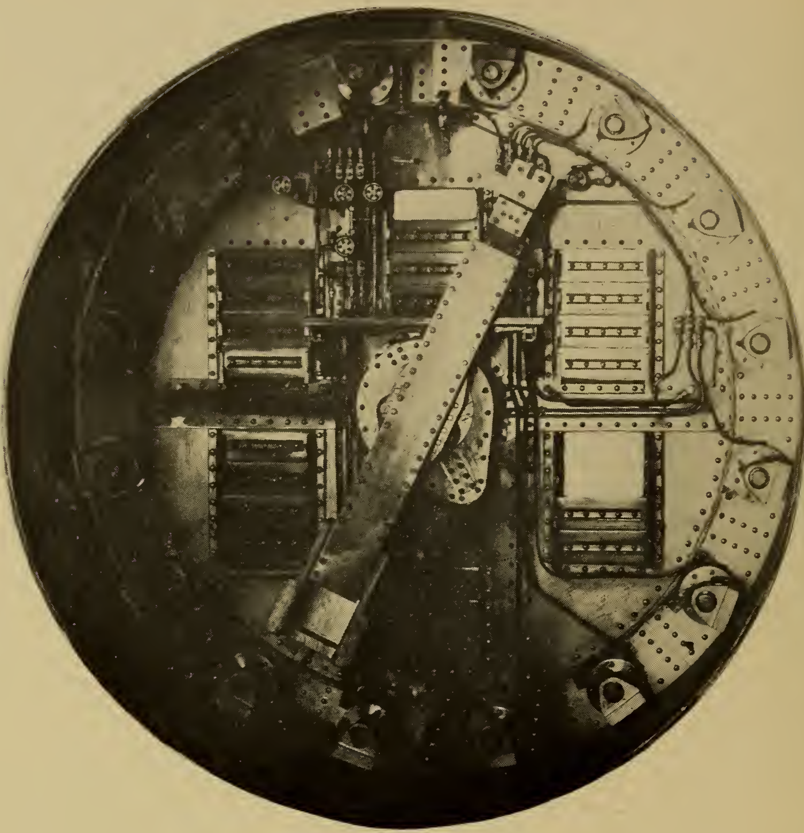
A variety of these tools are shown in accompanying illustrations. These include a 175-ton girder rail bender, a wire-rope shear for cutting 3-inch cables, a portable shaft straightener, arranged to be used in connection with a lathe, a 50-ton bond compressor and a 75-ton hydraulic punch.

Portable tools that are built to exert a great force are necessarily very slow when operated by a hand pump, and in order to do the work with greater despatch, large portable tools are sometimes arranged with a power pump mounted on the tool, and driven either by belt or an electric motor.

A 250-ton crankpin press shown in one of the illustrations is arranged in this manner. The pump, which has two plungers, is driven by a 3-H. P. motor. The beam of this press is 66 inches long, and it can be swivelled around to any angle. The distance to the center of the ram can be adjusted by four elevating screws, shown in the illustration.

Most machine shops are equipped with one or more of the portable tools enumerated above.

BROAD BASE HYDRAULIC JACK, MOUNTED ON WHEEL BASE



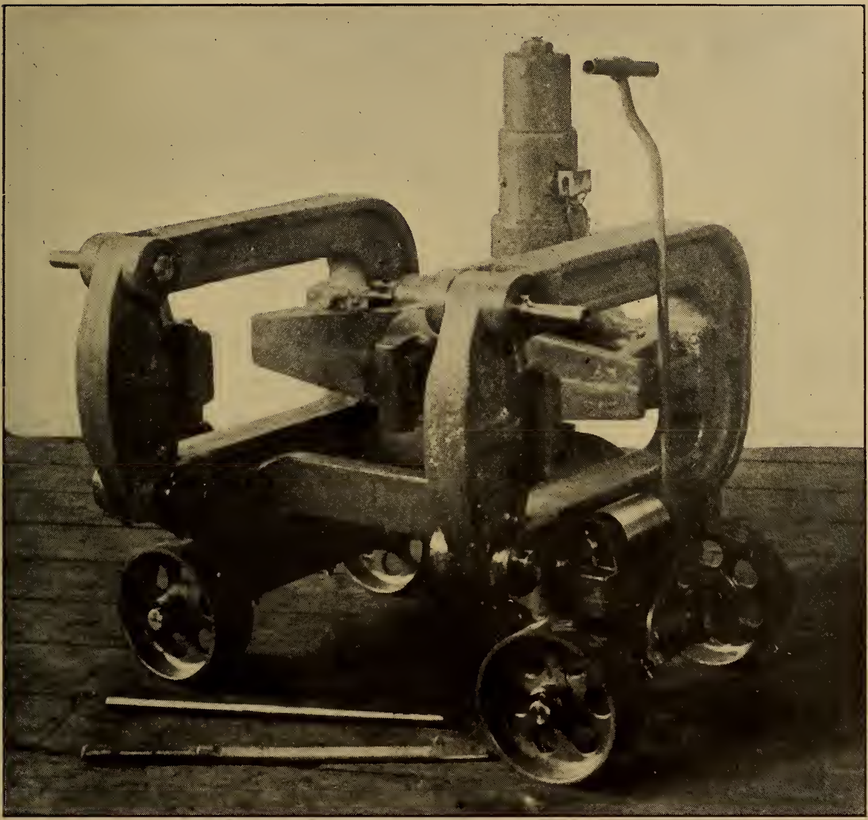
FRONT VIEW OF HYDRAULIC TUNNEL SHIELD. DESIGNED BY JACOBS & DAVIES. BUILT BY THE WATSON-STILLMAN COMPANY

Besides these tools, hydraulic presses of one or another kind are often used in machine shops, and where a regular pump and accumulator system is not introduced, the individual machines have to be operated either by belt or motor-driven pumps, generally attached to, or mounted on, the machine.

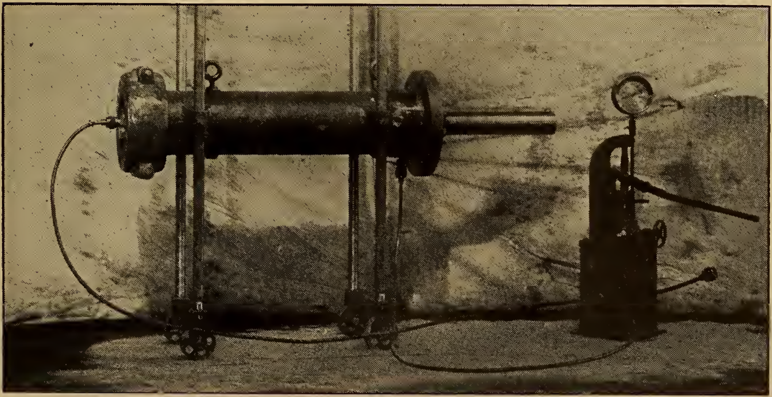
Among this class of tools we may mention the hydraulic broaching press, which is used for finishing square, hexagonal or oblong holes in steel or metal parts.

A 30-ton broaching press is shown in one of the illustrations. The press is belt-driven, a pulley operating a double-acting hydraulic pump. The cistern that contains the fluid is mounted over the cylinder on top of the machine. A double poppet release valve separates the cylinder from the reservoir. This valve can be tripped or opened by the small crank shown on the outside of the press. The plunger is furnished with rack and pinion mechanism, and the ram can be moved rapidly up and down with the handle attached to the pinion. When the ram is run out by the pinion, the cylinder is filled automatically through the poppet valve between the cylinder and cistern, and after the valve is opened by the crank, the ram can be returned to the upper position by the same pinion handle. The pump takes hold just as soon as the valve is closed.

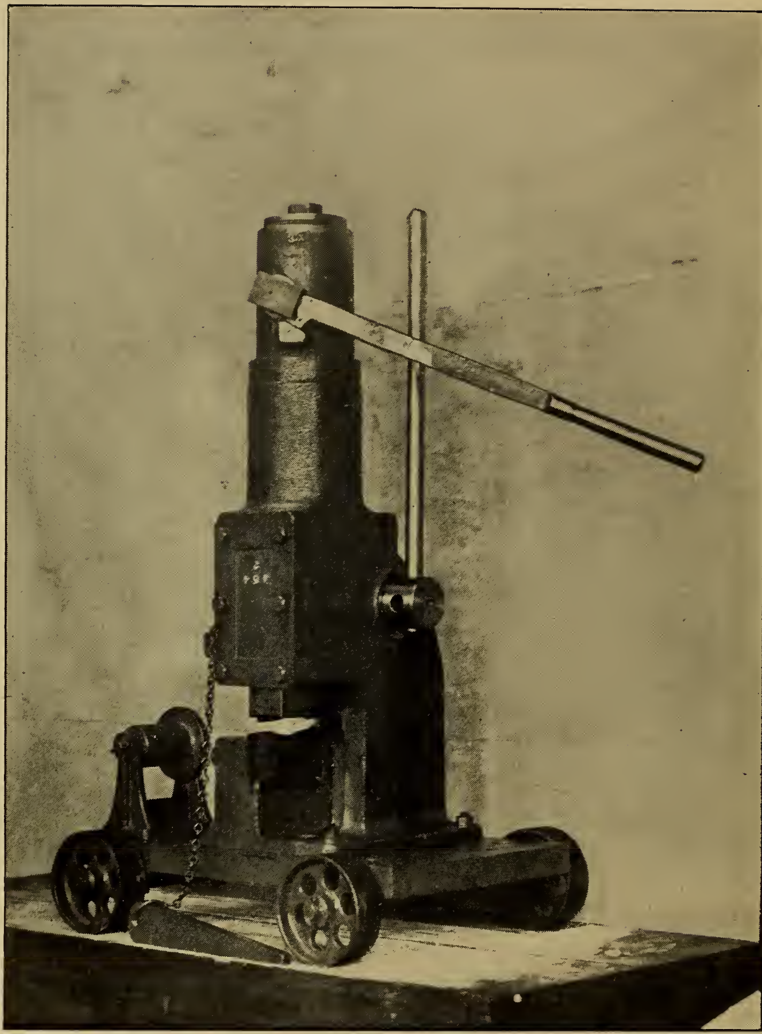
In the 30-ton press, square and hexagonal holes, with sides up to



GIRDER RAIL BENDER. 175-TON CAPACITY WATSON-STILLMAN COMPANY, NEW YORK



HYDRAULIC PULLING AND PUSHING JACK WITH DOUBLE PLUNGER HAND PUMP

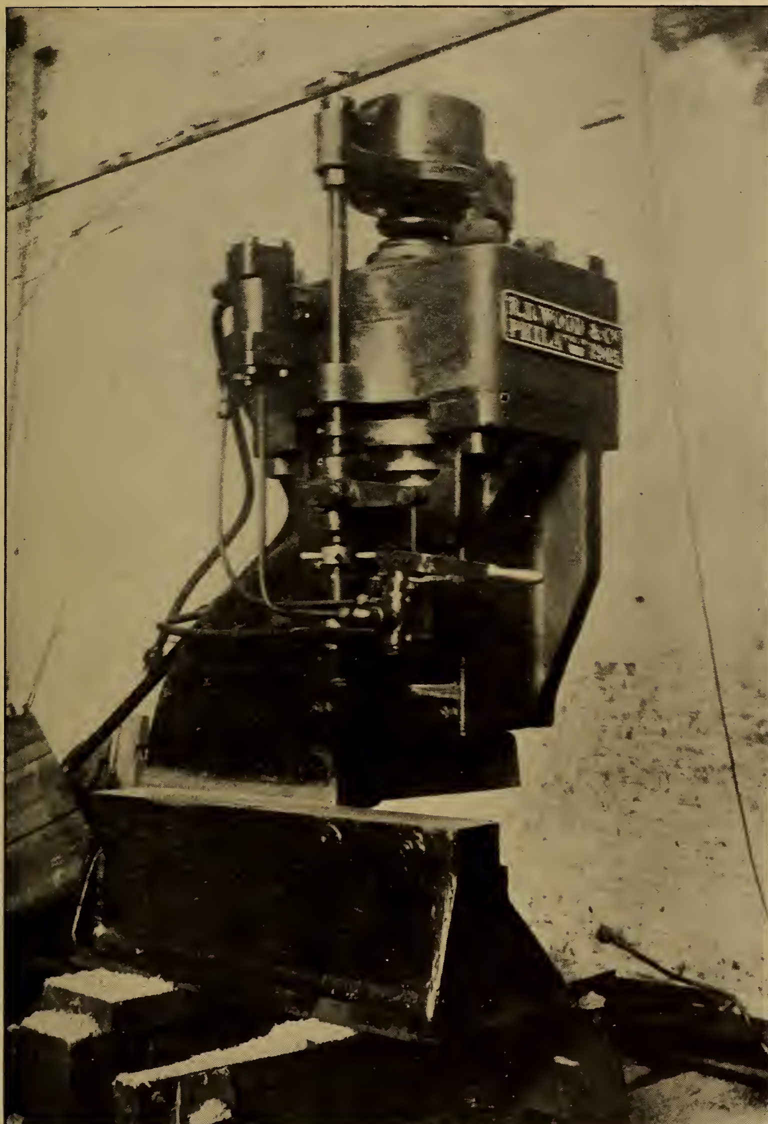


HYDRAULIC WIRE-ROPE SHEAR FOR CABLES UP TO 3 INCHES DIAMETER. WATSON-STILLMAN COMPANY

$1\frac{1}{4}$ inches wide, can easily be finished through $1\frac{1}{2}$-inch thick plates. One or more broaching cutters are used. These cutters are made slightly tapered, with teeth spaced $\frac{3}{4}$ inch apart. As the broaches are forced down, each succeeding tooth takes away a little more of the material from the inside of the casting, and the last or finishing tooth gives the exact size to the hole. Key-ways can also be cut in this machine in a similar manner.

Another type of press with attached pump, used extensively in railroad shops, is the axle-bearing press. This press is designed for removing locomotive axle bearings, and it is operated by a motor-driven pump. These presses can, of course, be furnished with belt-driven pumps. A small crane with chain hoist is attached to the top of the press. The function of this crane is to lift the work in and out of the press.

One of the most important tools in

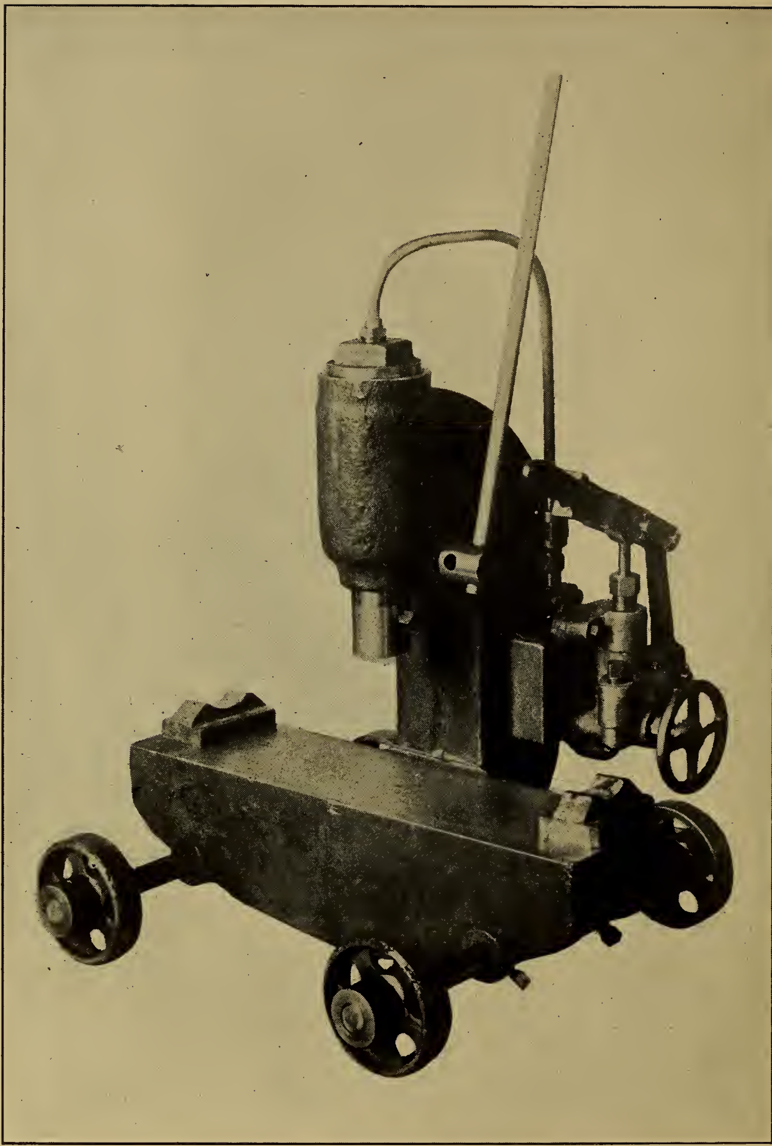


UNIVERSAL HYDRAULIC SPLITTING PRESS. R. D. WOOD & CO., PHILADELPHIA

a railroad repair shop is the hydrostatic wheel press, which is used for pressing wheels on and off car axles. These presses are made in all capacities and sizes from 60 tons up to 600 tons, and the distance between rods varies between 34 and 120 inches.

The press shown in accompanying illustration is of 400 tons capacity, with a distance of 90 inches between the tie-rods. The press is furnished with a two-plunger pump, and the arrangement is such that three speeds can be given to the ram. A 10-H. P. motor is connected to the pump by a Renold silent chain-drive.

We also wish to call attention to a novel feature in this wheel press,



HYDRAULIC SHAFT STRAIGHTENER. CAPACITY, 4½-INCH SHAFT; 50 TONS

namely, that four tie-rods are used instead of two rods, as is generally the number in most of the old-style hydrostatic wheel presses. The four rods prevent the press from springing sideways in case the strain should be a little outside the center of the press. The inclined type of wheel press is shown in another illustration. The object of the inclined frame is to allow the work to be lowered to the center of the press from an overhead crane without interfering with the tie-rods of the press.

The next article will deal with hydraulic tools operated from accumulator systems, and with hydraulic valves for distributing the fluid to the machines.

(To be Concluded.)

# Current Topics

AT the present time one of the subjects attracting earnest attention in engineering circles in the United States is the question of the conservation of the natural resources of the country. This is under consideration, not only by the National Government, but by technical and commercial bodies in various cities, and the country is evidently awakening to the fact that conservation, both of the ephemeral resources, such as coal, oil, gas, iron ore, timber, and the like, and of the hydraulic-power sources, is the great physical problem of the time.

At a recent meeting of the engineering profession, including members of the four great national engineering societies, held in the Engineering Societies building in New York, this important work was discussed from three viewpoints: the conservation of waters and woods; the conservation of the national fuel supply, and the conservation of stream-flow, water-power and navigation. To these was very appropriately connected the question of the relation of the engineer to the body politic, a matter which is at the foundation of the entire matter, being the realization by the general public of the truth of Tredgold's famous definition of the work of the engineer: "The art of directing the great sources of power in nature to the use and convenience of man." That the sources of power in nature have been thus directed by the engineer is fully conceded, but often in a manner altogether heedless and wasteful, and now it is the engineer himself by whom the alarm is sounded, and it is the engineer himself who is to show the way in which the waste is to be checked.

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IN his letter inviting the Governors of the various States to meet in conference in May in the White House, President Roosevelt has stated the question in his usual clear and forcible manner. There is no doubt that, as he says, the natural resources of the United States were, at the time of settlement, richer, more varied and more available than those of any other equal area on the face of the earth. Indeed, it is to this fact that the rapid settlement of the country by the vigorous, hardy and energetic races who have since so effectively developed those resources was largely due.

It is now time to take account of those resources, to make inventory of what remains, and so to handle them as not to destroy in advance all hope of prosperity in the future.

What the United States is now doing it is not too late for other nations also to consider. In Great Britain there has already been a Royal Commission occupied in the in-

vestigation of the coal resources of the United Kingdom. In like manner the supplies of iron ore have been investigated, both in Great Britain and in other countries. The question is not one for the United States alone; and especially is it important in colonial possessions, where the depletion has not yet reached an extent and rate sufficient to attract scientific attention.

Properly conserved, the natural resources of the world are ample to supply the wants of mankind for long ages to come; wastefully squandered, they may become at first restricted, then exhausted, and ultimately followed by conditions which, in the face of increasing population, can be viewed only with apprehension.

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AFTER considerable indecision, the German naval authorities have decided to add submarines to the fleet. When the construction of these under-water craft was first commenced by France, German experts professed to regard them as of dubious value, and no doubt at the time the particular experimental ships which were being built were of no great importance. At last, in view of the development of the submarine in the United States, the British Admiralty decided, in 1901, to build some boats of the Holland type, and in succeeding years seventy submarines have been authorized for the British fleet. Not until construction had made great progress in England and America did Germany decide to build such vessels. The first German submarine has recently been completed at the Germania shipyard at Kiel, and is a medium-sized vessel of 240 tons. The main dimensions of this vessel are: Length over all, 137.5 feet; maximum width across frames, 11.7 feet; draught of boat when emerged, 7.8 feet. An electric motor and gas engine, each with an output of 200 I. H. P., are fitted to each of the two propeller shafts, the motors being adjusted from the inside of the vessel. The electric motors are intended to propel the vessel below water, and receive current from an accumulator battery carried amidships. The battery is sufficiently powerful to drive the boat below water for fully three hours at its maximum speed of 9 knots. When on the surface, the gas engines will be used, as a rule. The fuel is carried in tanks arranged outside the boat (according to patents of the Germania shipyards), thus guarding against explosion. The store carried by the submarine enables her, it is claimed, to cover a distance of 1,000 knots at her maximum speed of 11 knots on the surface. The motors can obviously be used also for propulsion above water, while both types of motor can also be employed simultaneously for the propulsion of the vessel. The submersion and emersion of the boat are effected by filling and discharging the ballast tanks arranged inside, as well as by the aid of two pairs of horizontal rudders. The maximum depth of submersion has been fixed at about 120 feet, and only five minutes are required to prepare for submerging the boat. The ventilation is controlled electrically on the surface, and when the boat is submerged the vitiated atmosphere is subjected to a process of filtration. The submarine has a large conning tower in the centre of the boat. This is much more commodious than on the original type of the British submarine, so as to accommodate two officers, and two periscopes will be installed instead of one, as in the "A" type of submarine in the British service. Three torpedoes will be carried, and they will be of 18 inches. One will be in the launching tube and the other two in water-tight reservoirs. Normally, the vessel will have a crew of ten men, and these men will be able to travel under water, it is claimed, for as long as twenty-four hours without inconvenience.

# WILLIAM F. PARISH, JR.

A BIOGRAPHICAL SKETCH

WILLIAM F. PARISH, Jr., was born in Erie, Pa., January 9, 1874. Here his boyhood was spent in school and about the large machine shop of which his father was superintendent. While he was still a boy the family removed to Chicago, and he completed his education in the public schools of that city. Upon leaving school he went into the draughting-room of his father's company, and later became interested in the manufacturing end of the business.

In 1894 he accepted a position with a firm of sawmill machinery manufacturers and installed many plants in the South and West.

It was not until 1896 that Mr. Parish became directly interested in his present work. At that time he became associated with the lubricating department of the Standard Oil Company at Chicago, where he remained until the outbreak of the Spanish war, when he enlisted and served as an assistant engineer on the U. S. S. *Terror.*

In the spring of 1899 he associated himself with the Vacuum Oil Company, Rochester, N. Y., with the object in view of carrying on experiments in lubrication. The idea of making tests in manufacturing plants themselves to determine the power that could be saved by the use of suitable lubricants had been suggested to him by experiments which Dr. Thurston and Dr. Woodbury had performed in their laboratories and by his personal experience in the business.

For this purpose he went to Boston as chief of technical department for the Vacuum Oil Company, and soon began to develop his ideas. The scheme was to record at the prime mover the exact changes in power brought about by more efficient lubrication throughout an entire manufacturing plant.

To bring such a scheme down to a system in which variables would be eliminated and lubricating changes recorded was an undertaking requiring infinite study and experiment. The results of his work are given in the paper read before the National Cotton Manufacturers' Association at their annual meeting.

By 1903 Mr. Parish had organized a very efficient department at Boston, and had also started one in Japan, which was developing satisfactorily. The company felt that his services were needed elsewhere, and he was, therefore, sent to England, much to the regret of the many manufacturers who had been brought to an enduring interest in his work by his painstaking and scholarly investigations.

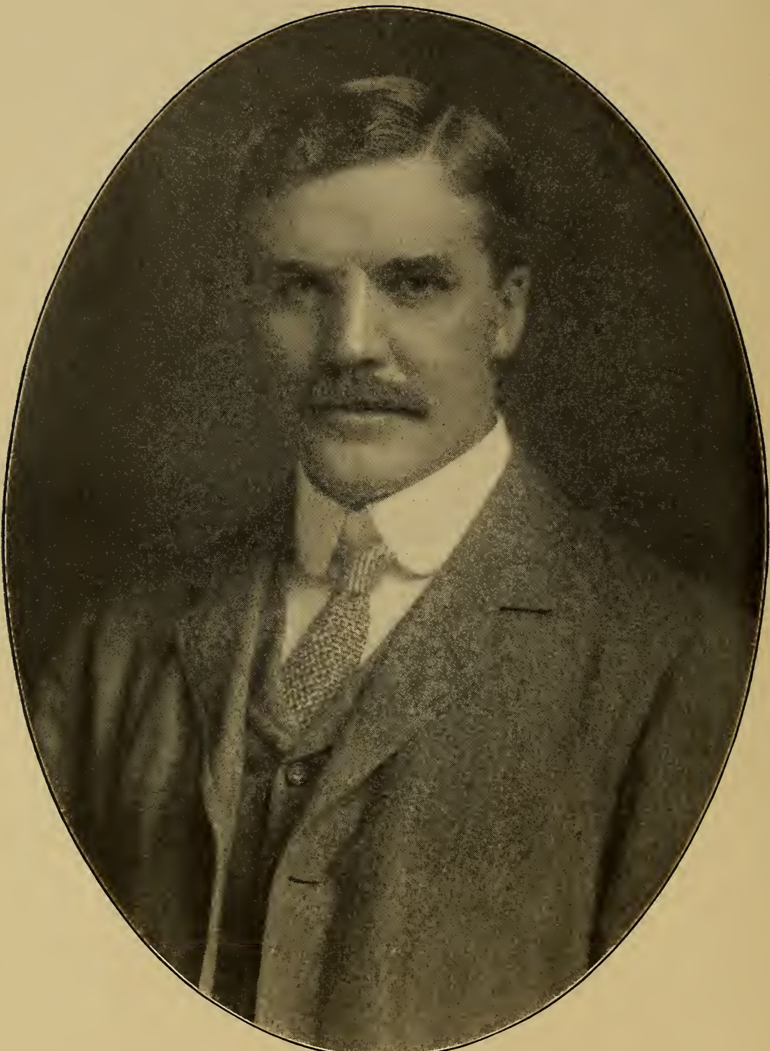
The next three years were spent in organizing departments in Great Britain and India, and much very valuable and interesting work was done. It was possible by 1906 to leave these departments to themselves, and he went to Germany. Here, and in Norway, Sweden and Russia, the next two years were spent in carrying on his work.

Mr. Parish is now located in Vienna, where he is organizing a de-

partment which has already obtained some extremely valuable data.

Several papers on the subject of lubrication have previously been read before the National Cotton Manufacturers' Association, of which Mr. Parish is an associate member. He is a member of the American Society of Mechanical Engineers and an honorary member of several foreign societies, before whom he has given the results of his investigations.

The company at present has departments operating in America, Japan, India, Great Britain, Germany, Norway, Sweden, Russia and Austria, with a force of over one hundred men, which Mr. Parish directs in an advisory capacity. He is to be congratulated upon his efforts in bringing to this subject the scientific attention which it deserves.



PHOTOGRAPH BY PACH BROS., NEW YORK

DUGALD CLERK, M. INST. C. E.

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CASSIER'S MAGAZINE

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# PROBLEMS OF INDUSTRIAL EDUCATION

By George Frederic Stratton

INDUSTRIAL education in the public schools has, up to the present time, been almost wholly introduced by pedagogical influence. Until very recently the fathers and the employers, who should be the most deeply interested in the work and the outcome, have not been consulted upon the ultimate practicability and value of such education so given, nor have they, indeed, shown a disposition to express their opinions upon the subject, except in a very infrequent and desultory manner.

School boards and superintendents have, therefore, not received the advice, suggestions and warnings, and perhaps restrictions, which should have been forthcoming from eminently practical men upon a subject so practical and important. Such men, while fully appreciating the great necessity of systematic training for a mechanical career, have been content to stand aloof and watch the results of the public-school experiments.

Under these circumstances it will not be surprising to find that the ideals of the public educators have drifted far from those of the public, and that "manual training" is by no means regarded by the instructors as a preparation for an industrial career. And yet very many men who are just awakening to these facts are surprised. The father, the tax-payer and the employer of labour are asking: "What is it all for—this 'manual training'—with its expensive equipment, its special teachers, and its demand upon the boy's time?"

And that question is growing decidedly insistent. A very careful scrutiny of a large quantity of published speeches and other expressions of opinion by public school authorities has failed to reveal a single claim that the industrial educational system, already existing in the graded schools or recommended for adoption, will fit the boy for entry into a mechanical occupation as a skilled workman.

A school superintendent, at a recent meeting of the National Society for the Promotion of Industrial Education, remarked:

"We are not teaching a trade; we are training the faculties of the children—training the observation, the imagination, the will, etc. We hold to a democratic ideal, which prevents us from condemning any boy to a life of hard labour. Every boy must have an equal chance in the public schools."

This view-point of the school authorities is somewhat severely, but

graphically, summed up in the following statement in the recent report of the Massachusetts Commission on Industrial and Technical Education: "The wide indifference to manual training as a school subject may be due to the narrow view which has prevailed among its chief advocates. It has been urged as a cultured subject mainly useful as a stimulus to other forms of intellectual effort—a sort of mustard relish—an appetizer, to be conducted without any industrial end. It has been severed from real life as completely as have the other school activities. Thus it has come about that the over-mastering influences of school traditions have brought into subordination both the drawing and the manual work."

It will be noticed that drawing is included in the above criticism. It is found in a very large majority of schools where manual training had been introduced that mechanical drawing is entirely subordinated to free-hand or ornamental drawing. The pupil spending two hours or more each week upon elemental bench work in some industry is also devoting a similar amount of time, not to mechanical drawing in that industry, but to free-hand, ornamental work. To the uninitiated, the graceful lines of the acanthus leaf contains so much more of interest and apparent skill than the hard correctness of the lag-screw or the mortise that the influence of the teachers is very generally enlisted in that direction.

This is another surprise to the many men who have been looking for some results from manual training in the schools to help meet the insistent demands for a better type of young mechanics. Of all the training in this direction that of mechanical drawing offers the easiest opportunity for the greatest utilitarian results; but that opportunity has been largely missed.

The ability correctly to read and understand working drawings of engineering or architectural work is as necessary for a first-class mechanic as the ability to read written instructions, and it is one of the points upon which the ordinary machine operator or floor-nailer of to-day is almost always deficient. A detail drawing of the simple part he is working upon comes, after due explanation by his foreman, within his comprehension; but the elaborate plan of the whole machine, or the whole building, is as obscure to him as a cryptograph. The lack of interest of which employers complain so much is due, in no small measure, to the inability of the workman to understand the entire plan of the work he is engaged upon—whether it be a railroad trestle, a factory building or an intricate machine. His interest, also, in the technical literature of the industry is frequently obliterated by this inability to understand the accompanying drawings. And the only way by which such understanding can come is through a course of strictly mechanical drawing. This point has been missed by many teachers. The acanthus leaf has been permitted to take the place of the lag-screw.

The tendency, undoubtedly, of a great many instructors is to regard manual training, in itself, as a golden opportunity for the dissemination of a larger understanding and appreciation of art. This view is very cleverly expressed by Miss Josephine Mahon, a high school teacher of East Orange, N. J., in a recent number of the "Manual Training Magazine":

"The high school age," she says, "is a period eminently fitted for the real beginning of the acquisition of the golden touch. At no time in life are the sensibilities more tender and the imagination more flexible. It is then that the beginnings of the underlying principles of harmony can best be taught. It is then that pupils can best be made to understand that a selfish enjoyment of the works of others is not enough, but that, with knowledge comes the duty of responsibility of action. It is their busi-

ness of life to create; it is their privilege. The great Creator has breathed it into them with the breath of life. This thought opens up for consideration the whole field of economics, and its relation to the subject of industrial education will readily be seen."

Truly the views of public school education upon "manual training" cannot be accused of narrowness. In fact, their breadth is a trifle overwhelming. Nor is any narrowness shown in the dissemination of these numerous advantages. In almost all schools where manual training has been introduced into the eighth or ninth grades every pupil is required to give some time to it, even if his ultimate profession as clergyman, physician, lawyer or merchant be already decided upon. Dr. Burton Lee Thorpe, in an enthusiastic little article on this subject in the "Dental Cosmos," even advocates manual training in the public schools as a foundation for dental education, and ingeniously cites in support of his argument the careers of some old-time dentists. He says:

"Since many of them were mechanics, who would gainsay that the preliminary training obtained in the occupations of blacksmith, barber, traveling tinker—all honorable vocations—did not make it possible for our professional forefathers to accomplish what they did? For instance, Hayden, whom we may safely denominate the "father of dental science," was a carpenter and architect; Eleazer Parmly was a printer by trade; W. H. Atkinson and W. W. Alport were both tailors' apprentices; Elisha Townsend was a watchmaker in his early youth; Elisha Neall, a traveling tinker, while many others followed similar vocations or obtained a crude manual training in early youth on the farm."

In the high schools there is a broad tendency to permit the students to select or reject the manual training course. Professor F. W. Ballou, of the University of Cincinnati, who recently gathered reports from 207 high schools, found that 159 permitted students to elect the course, while 48 made it compulsory.

It is true that the time devoted to manual training, even by those who will ultimately take college courses, is not so great as to cause the parents to lose any sleep over the matter. Referring again to Professor Ballou's report, we find that 106 schools give one and one-half hours per week, 68 give one hour, and 48 allow two hours; and some allow as little time as 25 minutes per week. That is all in the elemental grades. In the high schools he gives the following table:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 83 | high | schools | allow | 1½ | hours | each | week. |
| 25 | " | " | " | 2 | " | " | " |
| 20 | " | " | " | 4 | " | " | " |
| 11 | " | " | " | 2½ | " | " | " |
| 12 | " | " | " | 5 | " | " | " |
| 25 | " | " | " | 7 | " | " | " |
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All this is a very brief indication of the status of "manual training" in the public schools to-day; but it would be manifestly unfair, and entirely foreign to the purpose of this article, to present what appears to be an adverse criticism of the existing methods without touching upon the qualifying conditions and the good-meaning with which school authorities have organized the systems. Their assertions that the "busy work," "Sloyd work" and advanced "manual training" are valuable helps in training the faculties of the children—"training the observation, the imagination, the will," etc.—are not to be lightly treated, coming, as they do, from men and women of long experience in the science of pedagogy.

The trouble at this moment lies in the fact that the rapid growth of a demand for a larger number of bright, well-trained, young mechanics has turned all eyes to the possible sources of supply; and the men who, before this, should have acquainted themselves with those sources, now find, to their dismay, that there has been a "switch-off."

Those men are the great employers of labour—the manufacturers and railroad managers. Both find themselves in about the same position. Their business has increased by leaps and bounds, but their equipments remain as they were five or ten years ago. The railroad manager needs more trackage, more rolling-stock and larger yard facilities, and cannot secure them. The manufacturer needs more foremen, sub-foremen, experts on outside jobs, and fine repair men, and looks for them in vain. The men to build the locomotives and cars and to meet the rapidly increasing demands of all manufacturers are still in embryo. One of the largest contractors in New England, in a recent speech before his Board of Trade, said: "It is, in my opinion, useless to look for any relief from the manual training systems in the public schools as at present conducted. The manufacturer or contractor, who has to hustle for orders and make every dollar of capital earn 6 per cent. dividend and a little surplus for emergencies, can detect no value in art influence in the installation of the plumbing and heating system of a sky-scraper, or in the building and equipping of a great pumping station for the drainage of a city. The employers' hands are tied as to apprenticeship, and some modern and efficient system of industrial education by the municipalities or the State is becoming necessary if we are to hold our own in the industrial world."

One sentence in this quotation specially demands attention: "The employer's hands are tied as to apprenticeship." This is, of course, in reference to the fact that many trade unions place restrictions upon the number of apprentices to be taken in the trade.

There are probably but very few manufacturers whose hands are tied in this respect. The strictest unions allow an apprenticeship of 7 per cent. of the mechanics employed, others allow 12 per cent. An investigation made by the American Social Science Association showed that, of forty-eight unions with a total membership of half a million, twenty-eight, with 220,000 members, place no restrictions upon apprenticeship. Furthermore, the last United States Census reports that the total percentage of apprentices to mechanics was only 2.45.

But there is a newly-aroused sentiment in favour of apprenticeship since that report was made. Some of the largest manufacturers have devised systems so greatly in advance of the old methods that the results now showing are gratifying in a very high degree. Instead of the old seven-year course, the time is now four years. Separate shops are provided for the boys, where for the first year or two they are away from the workmen, but among diversified, practical tools and equipment, and under instructors specially engaged for the purpose. The conditions are ideal, and if such systems could be extended and be made generally available the whole problem would be solved. Nothing in outside training schools can compete successfully with the practical work of actual production under shop discipline and highly efficient instruction.

The manager of a large plant, where over 200 apprentices are being thus trained, was asked if boys who had taken the high school manual training course were credited with any time on his apprentice course.

"Not a day!" he replied emphatically. "How much could we allow them, in justice to the others? The total time they put in on a two years' course in the school is not over 160 hours—just about equal to three weeks of our time; and it is very doubtful to me if they have learned as much in that long drawn-out stretch of tuition as they would learn in three straight weeks in our shops."

But "what is" is not "what may be." It is only the larger manufac-

turers who can afford to thus equip a separate shop for boys and engage special instructors, and many of these men hesitate to go into the matter as deeply as they desire to for fear of what the unions may presently decide to do. Other manufacturers, for the same reason, refrain from adopting any apprentice system. The attitude of the unions may change at any moment, and the manager who has gone to great expense, both in equipment and organization, might find himself confronted by restrictions which would practically cripple his educational system. This is where many feel that their hands are tied, and that the only recourse is to State or municipal institutions for the thorough training of all boys who intend to enter upon an industrial career.

In most of the large cities and in many of the smaller ones the Boards of Trade are taking up the problem and calling upon the business men for suggestions and opinions. So far, all is chaos. Many are inclined to leave the matter in the hands of the school authorities, giving them appropriations for larger equipment and urging a post-graduate course for grammar school graduates—a course not connected with the high school, but one in which the entire time of the pupil would be devoted to industrial education. It is asserted—and good figures are submitted to back the assertion—that it is not among the high-school scholars that material for mechanics can be secured to a degree which makes manual training there worth while. Mr. Arthur D. Dean, State Supervisor of Industrial Education for the Massachusetts Young Men's Christian Association, and a deep student of the whole question, states that, of twenty-five hundred high school graduates of whom he had secured records and who had been obliged to take manual training, but 6 per cent. have taken up mechanical work.

A very serious objection or obstacle, however, comes up against an industrial course for grammar school graduates as proposed. It is pointed out that such thorough training cannot be given without the continual use of material, and that, unless a market can be found for the products, which is very doubtful, the expense of such material, added to the expense of furnishing tools and equipment and competent instructors, would be greater than municipalities would care to incur. It would undoubtedly arouse the antagonism of many tax-payers. A striking instance of this has recently occurred in New England. A gentleman connected with a great manufacturing company has become somewhat prominent for his progressive attitude on industrial education. He was recently invited to attend a meeting at Worcester, Mass., and there spoke eloquently and urgently in favour of a proposed appropriation of $40,000 for a municipal industrial school. Later he attended a similar meeting in his own town, where he as eloquently and urgently spoke against an appropriation of $8,000 for a similar purpose. As the company he is connected with is a heavy tax-payer in that town (and not in Worcester), it is easy to see that plans for industrial education are not having entirely disinterested advocacy.

In every phase of human endeavor records are watched and emulated, and successful examples are studied with a view to their adaptation to new conditions. Traveling this path and searching for valuable suggestions upon this very important subject, we find two existing methods of industrial and technical education which stand out with such excellent records of success that they are being looked into as available solutions of the vital questions: "Who to train?" and "How to train?"

These methods are the courses of the Young Men's Christian Association and the correspondence-school systems.

Bearing in mind the fact that a very small percentage of high school

pupils who have taken the manual training course enter industrial trades, and also that, of the grammar school students who are so trained the percentage of those who afterwards benefit by it is an unknown quantity—probably not over one-half—we are confronted by the fact that the time of pupils and instructors, also expensive rooms and equipment, are being devoted to effort which is unproductive of ultimate good result. We are considering only practical industrial education for the purpose of making fine mechanics. The first problem, then, is to determine, as nearly as possible, who are to be trained.

A study of the personnel of the young men who comprise the Young Men's Christian Association and the correspondence-school classes shows that they are, almost without exception, young workers already in their several trades. They have gone direct from the grammar schools, and sometimes the high schools, into industrial occupations, and their desire to become better men has drawn them into the classes mentioned. Here, then, is the true material; and the finest of material. Young, bright, enthusiastic men, perhaps compelled to work by the exigencies of their parents—perhaps eager themselves to at once enter upon the battle of life—but with it all, devoting two or three evenings each week to real endeavor at self-improvement. Such boys and men are worth while. Conversation with a large number of employers brings out the opinion—nay, the positive assertion—that their young employees who have followed up such opportunities for industrial and technical education are the men upon whom they are relying to-day for the best help and the best results.

"The best men I have," says the superintendent of a great machine shop, "are the few who have taken those evening courses or correspondence courses while working in here daily. Young men who will do that have the advantage of regular shop practice, which gives them manual training and the excellent technical education they obtain in their classes. They have character, too! A man, indifferent to his future and to his work, won't study nights. These night-students make good men and true—every time!"

But the work done by these two methods is necessarily limited. The Young Men's Christian Associations are in many towns but poorly equipped, financially, to do much of such work. And the correspondence schools, of course, require tuition fees, more or less large, according to the topic. Dollars are valuable to very many of these young men, or boys, just beginning to earn. The opportunity should be extended to all of them to secure such training at the expense of the community. In most public schools where manual training is now established, the change to evening classes would involve no extra cost for equipment or room. The students would be far less in number, for the reason that there would be no compulsory study, and only those who mean business would apply for admission. The large percentage of high school and other pupils who now absorb time and money in a very inconsiderable manual training—which is, after all, but a theoretical accessory to their general education, and will never be put to any practical use by them—would be eliminated, and the services of instructors and of equipment would be concentrated on a sound system of valuable training for those whose life-work is already commenced, and who can every day, if they will, see the great necessity for and value of the opportunities for improvement offered to them. The organization of evening classes for the industrial and technical education of young men who are already employees, an organization based upon common-sense, practical methods, would receive the hearty co-operation and support of parents and employers, as well as the tax-payers.

# THROUGH THE SCOTCH HIGHLANDS BY RAIL

By J. F. Gairns

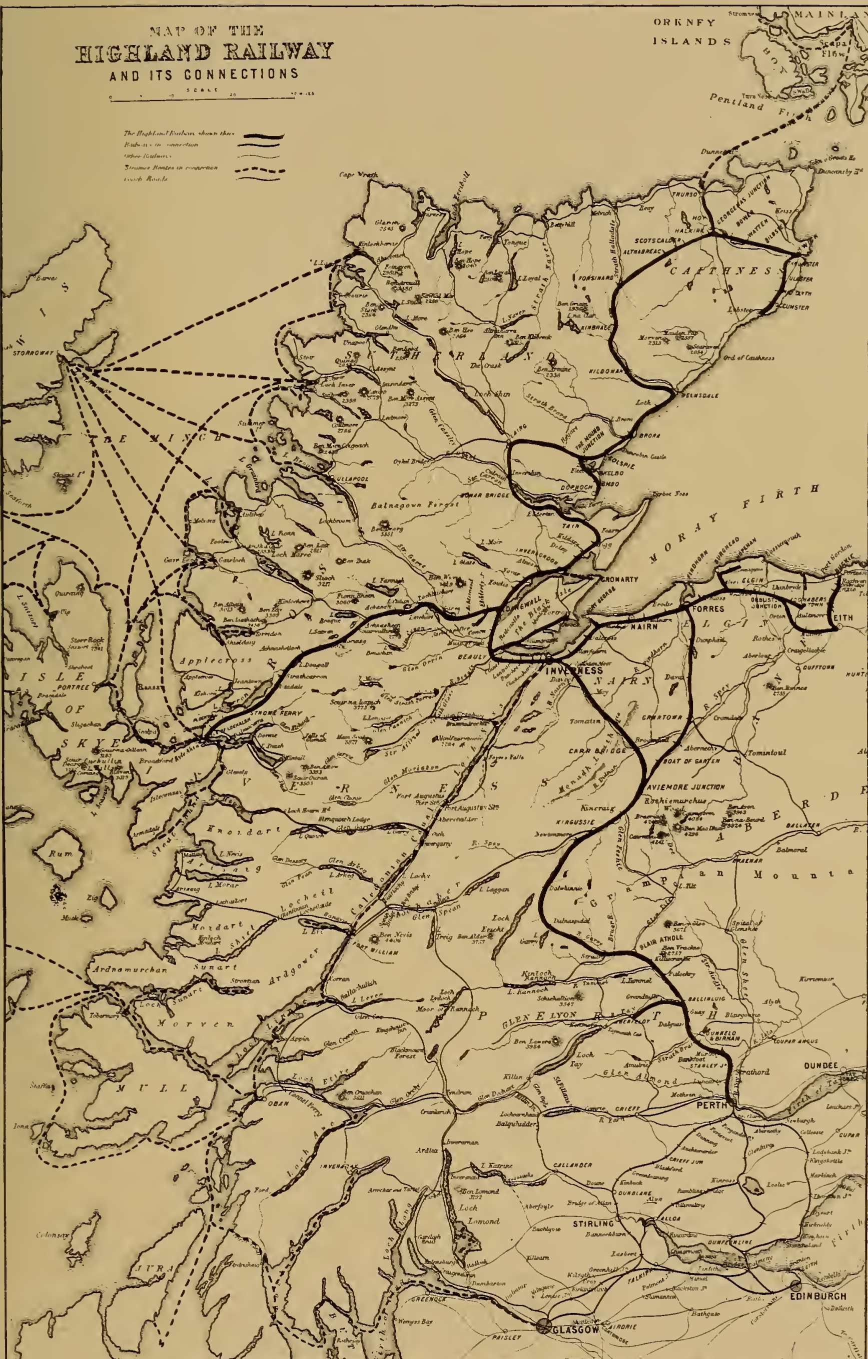
AS a general statement, it may be said that the railways of Great Britain do not traverse mountain districts, though in most cases there are, of course, many places where the geographical difficulties are considerable, and in numerous instances very hilly country is passed through; but there are two railways, besides a number of small lines which possess purely local interest, though most of them are more or less remarkable, which traverse mountainous districts, and on which the engineering works and traffic difficulties are more or less analogous to those which are involved in the case of those American and Continental railways which are generally referred to as examples of railway construction and operation under very adverse natural and climatic conditions. These two are the Cambrian Railway, in Wales, and the Highland Railway, in Scotland. It is true that many other lines penetrate similar districts, as, for example, the Caledonian, North British and Great North of Scotland Railways, in Scotland; parts of the Midland, North-Eastern, Furness, London & North-Western, Great Western and some of the smaller Welsh lines, in England and Wales, and some of the Irish railways; but in most of these cases the main lines over which express traffic is conducted are not concerned, or comparatively short distances only are through the mountainous districts, whereas both the railways specially mentioned are constructed for a considerable portion of their length through such districts. In the case of the Cambrian railway the speeds attempted are not high, and few of the trains omit more than a few of the stations, while the climatic conditions in winter are not specially unfavourable; but in the case of the Highland Railway, the main line, as well as important branches, is constructed through the heart of the mountains, the speeds of the express trains are very meritorious, in view of the grades and other difficulties, the loads of the principal express trains are very heavy, and there are many engineering works and features of traffic operation that possess special interest, while in winter the climatic conditions afford very serious obstruction and materially hinder the conduct of traffic, besides requiring special track construction and protection in many places. It is, therefore, thought that a short description of the line—which, it may be mentioned, is one possessing special scenic attractions—its construction, methods of dealing with the traffic and the means adopted for minimizing climatic difficulties, will be of interest, more especially as a remarkable series of photographs is available for illustrative purposes.

The southern terminus of the line is Perth, the general station of which is jointly owned by the Caledonian, North British and Highland Railways. At this station the two former railways hand over a considerable number of through vehicles from the large towns of England and Scotland to the Highland Railway for conveyance northwards to Inverness and the various Highland holiday and business centres. The Highland Railway itself extends northward of Inverness to the ex-


TABLET-EXCHANGING APPARATUS ON SINGLE-TRACK ROAD. THE TABLETS ARE EXCHANGED BY THE APPARATUS ON ALL THE SYSTEM WHILE TRAINS ARE RUNNING AT FULL SPEED

treme north and northwest of Scotland, reaching the most northerly towns, Wick and Thurso, of Great Britain. It is usually thought that the Highland Railway is a comparatively small system, and that the distances are short; but the distance from Perth to Inverness is 118 miles by the direct line (the old main line extends from Aviemore via Forres and Nairn and is 26 miles longer), the distance from Perth to Wick is 279¼ miles (161¼ miles from Inverness), and the Skye line (Dingwall to Kyle of Lochalsh) is 63½ miles long, and from Inverness the journey on this branch is 82 miles. It will, therefore, be seen that the journeys made by Highland Railway trains are of considerable length, and will compare favourably with those covered by many of the express and long-distance trains of other railways; and although north of Inverness the only trains that can really be called express run once a week only, on the Southern section, which is in many ways the hardest, heavy express trains are operated at very good average speeds. The whole system comprises 485 miles, and all of this is single-line, with the exception of about 34 miles. The sections are usually of considerable length—in several cases about 6, 7 or 8 miles long—so that on the upgrades as much as 20 minutes may often be occupied in traversing a section. Traffic is controlled by electric train tablet apparatus on the single lines, and this ensures almost absolute safety, while delays due to trains running out of order or out of time, so as to disarrange the train crossings, are minimized.

For the benefit of readers not familiar with this apparatus, it may be mentioned that for each section there are allotted a number of metal tablets, and these are fitted to electric apparatus at each end of a section, the construction being such that only one tablet can be out of the two apparatuses of each connected pair; and a driver is not allowed to enter or traverse a section without having




MAP OF THE HIGHLAND RAILWAY AND ITS CONNECTIONS

possession of a proper tablet. These apparatuses will each hold a set of tablets; but if a tablet has been withdrawn from one apparatus, say A, the apparatus becomes locked, so that no others can be extracted, nor can one be withdrawn from the connected apparatus at B until the one already out has been placed in that apparatus or replaced in the apparatus at A. The set of tablets can be distributed in any way, say four at A and two at B, or one at A and five at B; but however distributed, only one can be out of the two instruments at a time. By this arrangement it is possible to send several trains in succession in the same direction and to send a train either way, as required; but as only one tablet can be in use at a time, it is not possible for more than one train to occupy a section at the same time without breaking the rules, to do which constitutes the most serious offence a driver can commit. To facilitate changing the tablets as a train passes from section to section, the tablets are placed in leather pouches having a large looped wire handle, which can be caught on the arm while traveling fairly fast. This method is not really practicable for speeds higher than about 25 or 30 miles an hour, and to avoid the necessity for speed reduction of fast trains for this purpose tablet-exchanging apparatus is fitted to all the engines, and all fast exchanges are effected by means of this. Each engine has pivoted to the side of the cab a hinged arm, which, when lowered, extends horizontally outwards for about two feet. At the end are two spring clips, one for giving up a tablet (for apparatus-exchanging the tablets are placed in strong rectangular leather cases) and the other for collecting another one. Alongside the line at each crossing place is another apparatus similarly fitted, but adapted so that the arm swings automatically out of the way after an exchange has been effected. When a non-stopping train is expected, a tablet for the next section is placed in a case and fitted in the delivery clip of the stationary apparatus. On the engine the case containing the tablet to be given up is placed in the appropriate clip, and just before reaching the stationary apparatus the hinged arm is lowered. As the two devices meet, the case on the engine is caught by the receiving clip of the stationary apparatus (which then swings round out of the way) and withdrawn from the engine clip, and the engine apparatus similarly removes the case from the stationary apparatus, and the train can go on its way unchecked. Immediately on passing the fixed apparatus the hinged arm on the engine is raised out of the way by means of a foot lever or by hand. By means of this apparatus the exchange can be effected at the highest speeds, even up to 80 miles an hour, and the percentage of failures is hardly worth mentioning. If failure occurs at all, it is usually because speed is too low to open the clips properly; but at slow speeds exchange is usually effected by hand.

To enable a train to run through the crossing stations at speed, the junctions are usually so arranged that each train has a straight road at the facing end, the trailing junctions only being curved; but on the long grades, where trains in one direction are usually traveling slowly and in the other direction are generally traveling very fast, a straight road at both ends is, as a rule, given for the high-speed direction. The crossings are usually very long, so that there is ample margin for the longest trains; but a train, even if timed to stop, is always checked before reaching the crossing by signal if a train in the other direction is not already on the double line of the crossing. All the stations are fully signalled according to British practice, though there are several cases where stations are not adapted for crossings and there is only the one through line and single platform, with, perhaps, one or two

THE HIGHLAND RAILWAY. KYLE OF LOCHALSH RAILWAY STATION AND PIER

sidings, which are controlled by what is known as Annett's key. This apparatus can be released only by a proper tablet for the section concerned, which is appropriately shaped for the purpose, so that safety is amply provided for.

A few remarks concerning the line itself and its gradients will now be in place before considering briefly the train services, rolling-stock, traffic and some of the climatic difficulties involved.

THE HIGHLAND RAILWAY. POUCH MAIL TRAIN PASSING AVIEMORE

The most important towns on the railway are Perth and Inverness, the latter, which is sometimes referred to as the "Capital of the Highlands," being the headquarters of the Highland Railway; and at an early date in the history of railways it was proposed to construct a railway to connect these two towns. This was in 1845, when Parliamentary sanction was applied for for the construction of the line; but the bill was rejected, as it was considered impossible to conduct railway traffic on a gradient of 1 in 75 for miles except with a rack rail.

The project was revived in 1853, but with no better success; and it was not till 1861 that a new "Inverness & Perth Railway Company" obtained Parliamentary sanction for a line over the Grampian Mountains. In the meantime, however, a successful effort had been made to secure railway connection with the south by way of Aberdeen in conjunction with the Great North of Scotland Railway. A line was completed in 1855 between Inverness and Nairn (15¼ miles), and it was at first intended that the Inverness and Great North Companies should join hands at Elgin; but, owing to financial difficulties of the latter railway, the Inverness & Nairn Railway was extended to Keith, which is still the eastern terminus of the Highland Railway. This route, opened in 1858, was, however, too circuitous to be satisfactory. A railway through the Central Highlands between Forres

EXPRESS LOCOMOTIVE FITTED WITH CINEMETOGRAPHIC APPARATUS FOR PRODUCING MOVING PICTURE FILMS

and Stanley was authorized in 1861, and was completed and opened two years later, its construction being considered one of the smartest pieces of railway engineering witnessed up to that time.

The route thus provided between Perth and Inverness was used until 1898, the trains traveling from Aviemore to Inverness via Forres, where connection was made with the Inverness & Keith line; but in that year a new, direct line was constructed between Aviemore and Inverness. This short cut, which proved a most expensive undertaking and involves some heavy engineering features, shortened the distance between Aviemore and Inverness from 60½ miles to 34¾ miles. This line crosses a section of the Monadliadh Mountains at a height of 1,323 feet, and crosses the valleys of the Findhorn and Nairn Rivers by viaducts, which rank among the largest and finest specimens of stone and iron work in the kingdom.

Proceeding northwards from Inverness, the Inverness & Dingwall line was opened in 1862; extended to Invergordon in 1863, and to Bonar-Bridge in 1864. The Sutherland Railway, from Bonar-Bridge to Golspie, was made in 1868; the Dingwall & Strome Ferry line in 1870; the Golspie & Helmsdale extension in 1871, and 1874 saw Wick and Thurso in railway communication with Inverness and the south. All these schemes finally became "The Highland Railway" in 1884.

Another important addition to the system was completed in 1897 in the extension of the Skye line from Strome Ferry to Kyle of Lochalsh, a portion of the original scheme which had, at the time, to be abandoned owing to engineering difficulties and the lack of financial resources. The important island of Skye is now, by ferry, within five minutes of the mainland, and piers have been constructed in order to concentrate and accommodate the west coast traffic at this convenient point. The last section of this line

is claimed to be the most expensive piece of railway construction ever executed in the north, and it adds an interesting ten miles to the system. Its cost—£170,000, including piers—was defrayed to the extent of £45,000 by the government of the day. To facilitate further the traffic on the Perth section, which is apt to get blocked in the summer and autumn owing to the rushes of traffic, the line between Dalnaspidal and Blair-Atholl, 17½ miles, has been doubled, and doubling is being extended north and south.

The large station at Perth is worked by a joint committee appointed by the Caledonian, North British & Highland Railways, and the trains of the latter railway use Caledonian metals as far as Stanley (7¼ miles), where single-line Highland territory is immediately entered upon. As far as Blair-Atholl (35¼ miles) the grades are not specially severe, though by no means easy, and practically all ascending from Perth. On the northward journey the speeds of express trains and of slow trains between stations are fairly high, while high speeds on the southward journey are the rule; and no reductions are made when passing non-stopping stations, notwithstanding that at most of them "tablets" have to be exchanged, as already described, when passing from one section to another.

Before reaching Blair-Atholl the line traverses the Pass of Killiecrankie, which possesses considerable historic interest, most of this section being built upon a rocky ledge cut from the side of the pass. At one place the line crosses from one side to the other by means of a large stone viaduct about 40 feet in height and consisting of ten arches of 35 feet span. This viaduct is constructed on a curve and affords a very fine view of the pass.

THE HIGHLAND RAILWAY. DUNROBIN, PRIVATE STATION FOR DUNROBIN CASTLE, SEAT OF THE DUKE OF SUTHERLAND

Leaving Blair-Atholl (where an assisting engine is usually attached, unless there are already two engines from Perth, as is sometimes the case) the train commences the long, steep climb across the Grampian Mountains. For 16 miles the Highland engines have to grapple with the hardest task allotted to any

STRUAN VIADUCT. MAIN ROAD BRIDGE AND RIVER GARRY. STRUAN STATION

British locomotives, the line rising, by grades mostly at 1 in 70, to a height of 1,484 feet a short way beyond Dalnaspidal station—the highest point reached on any railway system in the kingdom.

This section is wild and bare through the heart of the mountains, and, owing to the length of the pull, the speed falls considerably, thus evidencing the difficulty of the work required of the engines (several trains load up very heavy over this section). As the distances between stations are long and the time occupied in traversing a section may easily be 20 minutes or more, and to minimize delays if trains are out of order, thus upsetting the crossing arrangements, this section is largely doubled, and will be double-line throughout at an early date. At the County March summit the pilot engine is detached, unless it is to go through, and the same is done with southbound trains, if assisted, though the gradients are easier from the north and seldom exceed 1 in 100, though one part is at 1 in 80.

The direct line from Aviemore to Inverness cost about £750,000 for the 34 miles, and forms a very difficult section, grades of 1 in 60 abounding. Pilot engines are taken both ways to Slochd Crossing. From Inverness there are about 10 miles continuously at 1 in 60. There are long and deep cuttings and many lofty bridges and long viaducts on this section. The Dulnain Water is crossed close to Carr Bridge station by a steel girder bridge resting on granite abutments, and having a span of 180 feet and standing 56 feet above the bed of the river. Connecting the bridge with the opposite side of the hill is an embankment, 45 feet high, and composed of 140,000 cubic yards of material. A quarter of a mile from Carr Bridge station the train enters what is known as the Dalrachy cutting through mountain clay, mostly 50 feet deep, and the excavations took

three years to accomplish. Turning to the left, the line crosses the Bogbain and Altnashannich burns four times—winding in and out, now in cutting, now on embankment, before reaching the Slochd Pass, about four miles from Carr Bridge. The railway is formed in the centre of the gorge, the sides of which rise on each side to a height of 200 feet. Before entering the pass the line swings round the hillside on a half-mile curve, on a rising gradient of

THE HIGHLAND RAILWAY. FINDHORN VIADUCT

1 in 70, and crosses the gorge at right angles by a viaduct of 8 arches of 37 feet span, at a height of 105 feet.

Five miles from Carr Bridge the summit level of this section of the line (1,323 feet) is reached, and here occurs the Drumbain cutting, the largest on the whole line between Aviemore and Inverness. For a considerable portion of its length the depth is 56 feet, and by the time it was completed the amount of material excavated was calculated at 350,000 cubic yards. As the winter in this elevated region is generally so tempestuous that work had to be suspended for four of five months at a time, it was a very formidable and protracted undertaking. At the upper portion of the cutting a great depth of moss was encountered, in which, at a depth of 25 feet, three successive crops of fir could be traced, each buried 3 feet under the other.

At Tomatin the valley is steep and narrow, and costly works had to be undertaken to get the railway across. The viaduct spanning the river is a large one. It is 445 yards long, and rises to a height of 144 feet above the bed of the river. There are nine spans of 130 feet, with arches of 36 feet span at each end. The piers are built of granite, and the superstructure is of steel. A peculiarity is that the whole viaduct is constructed on a curve of half-a-mile radius, and has a grade of 1 in 60, falling northwards. Immediately beyond there is another viaduct constructed entirely of granite, also hav-

NAIRN VIADUCT, NEAR CULLODEN-MOOR STATION

THE HIGHLAND RAILWAY. KYLE OF LOCHALSH STATION


4-6-0 EXPRESS ENGINE DESIGNED BY M. P. DRUMMOND

ing nine arches of 36 feet span; height from 40 to 60 feet.

Near Culloden Moor station is the Nairn Viaduct, which is one of the largest and loftiest stone railway bridges in the kingdom. It is approached on a curve by an embankment 50 feet in height, and is 600 yards long. It consists of twenty-eight arches of 50 feet span, and one across the river bed of 100 feet span. From the bed of the river to the level of the rails the greatest height is 130 feet.

In the journey from Aviemore to Inverness no fewer than 150 bridges of various sizes are crossed, and four viaducts—two of them exceptionally large—and the total amount of earthwork necessary in forming cuttings and embankments amounted to considerably over two million cubic yards.

Via the old line between Aviemore and Inverness the grades are also very severe, there being much at 1 in 80, and assisting engines are stationed at Forres for use when required. At one place there is a long embankment 77 feet high. A short distance beyond Forres the rapid and dangerous river Findhorn is crossed by a tubular girder bridge, comprising three spans of 150 feet, with stone piers.

From Inverness northwards the railway skirts the shores of the Beauly Firth for over 10 miles, the direction being almost due west of Inverness, a detour which it was impossible to avoid without bridging the Firth itself. Starting from the north side of the Inverness station, the line crosses the river Ness immediately above the harbour by a stone viaduct, consisting of five arches of 73 feet span, and a mile onwards reaches the Caledonian Canal, which is crossed by a swing bridge.

From Dingwall branches off the Skye line, and local trains are also run from Dingwall to Strathpeffer Spa.

As far as Bonar-Bridge the grades are not specially severe; but then follows 22 miles, much at 1 in 70, and the summit at Forsinard is approached in both directions by grades at 1 in 60, 70 and 80. Near Brora there are coal mines which, after being long discontinued, were reopened in 1872. Onwards the grades are comparatively easy; but the whole northern part of the line is very exposed, and the winds are often very

high. In fact, in this part of the country there are no trees worthy of the name, a large shrub being the nearest approach thereto, and in places there are deep peat morasses. The dwellings of the peasantry were, and still in parts are, poor hovels, built of turf and stone in alternate layers, and thatched over with straw or sods, which are kept down by straw ropes thrown across the roof, to the ends of which flat stones are attached as safeguards against the violence of the winds. Yet the agricultural products of Caithness County are greater than those of some others of the northern shires, and its advances in agricultural improvements, and in rearing the finest breeds of cattle, have, of late years, been very marked. This section is one of the most difficult to keep clear in time of snow. Aultnabreac station is famed for its snow drifts, and perhaps no portion of the Highland Railway is so readily blocked by winter storms. For many miles snow fences are erected on one or both sides of the line about 10 yards apart, and in places these are arranged at an angle of about 30 degrees from the horizontal, so that snow carried across the line by high wind is deflected onwards, to deposit on the further side. Such snow fences are also employed for long distances on other parts of the line, and their erection and maintenance is a serious item of expense.

Near Kildonan station is the scene of the Sutherland gold diggings of 1868-9, when the discovery of a small amount of the precious metal in the beds of the rivers caused a short-lived "rush" to the district. The diggings were again experimented upon in 1896; but gold was not found in paying quantities, and further search has been prohibited.

A SNOW BLOCK ON THE HIGHLAND RAILWAY

The Skye line, from Dingwall to Strome Ferry and Kyle of Lochalsh, is probably the most remarkable section of the Highland Railway from a scenic point of view, interesting though most of the sections are, and the engineering works involved are very severe. The line cuts across from the east to the west coasts, and was constructed with the object of providing railway access to the islands of the Hebrides, many of which are of considerable importance and size, though, so far as the writer is aware, there is no railway in a single one of them. Until 1897 Strome Ferry was the terminus of the line, but it was considered desirable to extend the line to Kyle of

Lochalsh. The line winds round the southern shore of Lochcarron mouth for 10 miles to the new terminus in wonderful curves along the rocky shores of the loch, sometimes working round the points and spurs and sometimes driven through them. The new portion presents a series of deep, narrow, rugged rock cuttings, whose inner sides rise perpendicularly to from 40 to 70 feet, while the outer or sea-side walls resemble high-buttressed dykes—all that has been left by blasting operations between the line and the water.

From Dingwall the line is interesting enough, especially when one travels on the engine, as the writer was permitted to do, with long grades, including one stretch of several miles at 1 in 40 and 1 in 50, and in continual company of mountain and loch; but the final section far surpasses it. In many cases it appears from the engine as if there is no way through the rock, owing to the cuttings being on curves; but as the grades are fairly easy, the section is taken at considerable speed, almost the whole distance being fitted with check rails and properly superelevated, and Highland drivers are not afraid of taking their curves at speed. On this section watchmen are employed in case of rock falls, and their huts are provided with telephonic communication. None but bogie engines are allowed on this portion of the line, and double-heading is prohibited. For the construction of the terminus at Kyle of Lochalsh an extensive level, triangular area has been formed by blasting and quarrying, tapering from the narrow width of the single line at the inland angle to a stretch of several hundred feet along the seafront, where shipping wharfs have been erected. The station occupies the centre, and broad platforms for passenger and goods traffic are provided. Directly opposite, and connecting by ferry with the village of Kyleakin, is the island of Skye.

All the older locomotives, except a few tank engines, are of the 4-4-0 type, with outside cylinders and coupled wheels about 6 feet in diameter, except in the case of a class designed specially for the Skye line having wheels about 5 feet 6 inches in diameter. For use on the northern and eastern lines there is also a class of inside cylinder engines with 6-foot coupled wheels, designed by the present locomotive superintendent, Mr. Peter Drummond. For express traffic between Perth and Inverness, however, the standard locomotives are large 4-6-0 outside-cylinder engines with 5-foot 9-inch coupled wheels (the "Castle" class), designed by Mr. Drummond, and the bulk of the trains are worked by these or by the largest class of outside-cylinder 4-4-0 engines (the "Loch" class), which constituted the last design introduced by Mr. Jones before his death in 1896. The pilot engines on this section are usually of the "Loch" class. These engines, when constructed, were fitted with piston valves; but, owing to the long downhill "coasts" without steam, it was considered desirable to replace these by ordinary D slide valves. For goods traffic, though these are often used for passenger traffic, Mr. Jones introduced a class of 4-6-0 engines with 20-inch by 26-inch cylinders and 5-foot 3-inch coupled wheels. It is worthy of remark that these were the first 4-6-0 engines in Great Britain, but these are confined to the southern main line: on the northern section there is a class of six-coupled, inside-cylinder goods engines (0-6-0 type) of Mr. Drummond's design, and these are often used for passenger traffic as well.

Between Perth and Inverness some of the trains are very heavy. The principal night trains from London by the three routes (East Coast, West Coast and Midland & North British) all converge on Perth about 5 A. M.; and the through vehicles, many of which are sleeping-cars and all of which are large eight-coupled or twelve-wheeled bogie cars of the

A CUTTING ON THE SKYE RAILWAY LINE

largest and heaviest types, are combined as one train, unless the load requires division, as is frequently the case. Even then the loads may be ten or twelve of these vehicles, amounting to between 300 and 400 tons; and it is remarkable work for a "Castle" engine with a "Loch" as pilot, either for the hardest grades or throughout, as is often the case, to work such a train from Perth to Inverness in 3¼ hours, with four or more stops. The return train leaves Inverness at 5.30 P. M. Several other trains are nearly as difficult to work, and occasionally the "Castle" engines work really heavy trains over the stiffest grades without pilot assistance. In other cases two "Lochs" are employed; but the combination of a "Castle" and a "Loch" seems to meet all require-

A 1 IN 50 GRADE ON THE SKYE RAILWAY LINE

ments, however severe. With all these engines speeds often exceed the mile-a-minute rate on the easier and downhill sections, while an average speed of about 35 miles per hour between Perth and Inverness with such loads must be considered a remarkable achievement.

North of Inverness there is not much express traffic, for all the regular trains require to serve most of the stations, as the traffic is so small that it is not worth providing both slow and fast trains. In fact, north of Helmsdale some of the stations have only one or two trains daily. On Fridays a "Furthest North" express runs from Inverness to Wick, returning south on Thursdays, and this train stops only at Tain, Bonar-Bridge and four or five other stations beyond, taking 4 hours 50 minutes

for the 161¼ miles to Wick, as compared with 6 hours by the fastest ordinary train. Many of the trains north of Inverness are fairly heavy, but nothing to compare with the special loads taken south, and the smaller engines, which are rarely piloted, deal with them very efficiently.

In August and September the "rushes" to the north for shooting entails very great difficulty upon the Highland Railway, it being by no means unknown for nearly forty sleeping-cars to be handed over at Perth in the course of a single night; but, although there is a good deal of special holiday traffic during the summer, it is not properly balanced, and a considerable amount of empty running is necessary to return the vehicles, thus materially diminishing the financial value of the traffic. Fish and cattle traffic is very extensive, and in the former case the trains, which are often "special," have to be run at express speed for transfer to other Scotch and English lines for transport to the large towns of England and Scotland. In fact, so important are some of these fish specials that the ordinary passenger trains sometimes have to give way to them. There is a very large mail traffic carried by the Highland Railway, there being carrier wagons and other motor-car services in various directions from nearly every station to provide mail communication with the villages remote from the railway. Many of the stations are provided with apparatus for exchanging the mails at speed. In winter, however, the trains are very considerably reduced, as the traffic requirements then become very light; but in times of storm, especially with snow, it sometimes becomes very difficult to conduct the traffic, for on the exposed parts there is usually the combination of high wind and snow, so that unless adequate measures are taken in time, there is risk of the various cuttings being blocked. The last time a serious snow block occurred on the Highland Railway was in 1881, when the line near Aultnabreac was blocked for nearly three months, with the exception of five days, and at one time, with 112 men and three engines with a snow plough, only 77 yards could be cleared in eleven hours, the snow being, in places, 30 feet deep. In later years, however, all serious blocks have been avoided by running light engines, two or three together, with a small, medium or large snow plough attached to the front engine, to and fro through the affected sections directly there are signs of a snowstorm, while the scientific location and design of snow fences has materially protected the line.

The railway works are at Inverness, and are of considerable size and comparatively modern and up to date. Most of the locomotives and some of the vehicles are built by outside firms, but the railway works can provide for most of the requirements of the line. Much more information concerning the line could be given; for example, it may be mentioned that, for about 30 miles, old rails are employed as telegraph poles; but enough has been said to indicate that the Highland Railway is one of considerable interest in many ways, and is unique in more respects than one, while it presents many characteristics that are not found, except in a minor degree, upon any other British railway, or, perhaps, on any other railway in the world.

The writer is indebted to various officials of the line for much information and for facilities for personal inspection, as well as for the provision of the photographs reproduced herewith. Of these gentlemen, must be mentioned Mr. Whitelaw, chairman; Mr. T. A. Wilson, general manager; Mr. McEwen, traffic manager; Mr. Peter Drummond, locomotive superintendent, and Mr. A. Cameron, advertising agent.

# THE DEHYDRATION OF AIR

By Joseph H. Hart, Ph. D.

*With the pressure of modern business conditions. the smaller economies, formerly hardly worth investigating, are looked to to enable competition to be met and profits to be earned. Among possible sources of efficiency the elimination of moisture from the air, which is so often used in industrial operations, is known to be an important factor, and methods which formerly were considered as available only for the laboratory are now used in the factory and workshop. Dr. Hart examines some of these methods and their applications, showing how scientific processes for the dehydration of air are applicable, in many cases to great advantage.*—The Editor.

THE problem of dehydration of the ordinary atmosphere for its more efficient utilization in various commercial or engineering developments is not one that has appealed, as yet, to the average engineer or one with which he is at all familiar. The small proportion of water vapour present in the air, although with its deleterious effect in many industries is still recognized, has generally been considered of too small account for active consideration in regard to its removal. Again, the minute size of this factor has led to the belief that no efficient method for its elimination was possible, although until recently very little knowledge outside of the physical laboratory was to be had in regard to its amount and variation under different conditions. To-day, however, it is generally recognized that it can be efficiently removed by a number of different processes, and is a distinct step in advance in many industries, and has increased the efficiency of their processes enormously. This increase in efficiency is due to a large number of factors, all of which are affected favourably in some industries, and in others the different factors may occasionally be affected so that their influence is rather to diminish the efficiency.

In order to realize the extent to which this development has progressed and its possibilities in future installations, we will cite the case of its utilization in blast-furnace operation for the manufacture of iron. The application of dry-air blast obtained by means of refrigerating machinery has been successfully and economically employed in the Pittsburg district. A single citation of the conditions of operation of the Isabella furnace at Etna, Pa., will give an idea of the size and possibility of the development. This furnace produced 350 tons of iron with 2,147 pounds of coke per ton of output, and consumed approximately 40,000 cubic feet of air per minute. The refrigerating plant installed consisted of two ammonia compressors of a nominal capacity of 225 tons of ice-melting effect each. One only of these compressors is generally operated, and the other is held in reserve to help out on especially humid days. The air was cooled from 80 degrees to about 28 degrees F., and the moisture content was lowered from 5.66 grains per cubic foot, as existing in a special test, to 1.75 grains. The air handled after the blowing engines were slowed down, on account of increased density and removal of the moisture, was 34,000 cubic feet per minute. About ten tons of water was collected per day, and the output was increased to 450 tons of iron, with a coke consumption of 1,729 pounds per ton of output. The blowers were slowed down from 114 to 96 revolutions per minute and the air was reduced in amount as stated, and the indicated horse-power of the blowers from 2,700 to 2,013, thus showing a saving of 687 horse-power in operating

the blowing engine. As the refrigerating machinery would only require about 530 horse-power when operated at its maximum capacity, the saving in this factor alone was considerable. In addition, the quality of the iron is improved and can be made very constant in character. The ore and fuel were of uniform condition formerly, but the humidity of the air was very variable. It may vary in one day from 20 per cent. to 100 relative humidity, and this may mean a variation of 300 per cent. total in the complete water content for each grain of water vapour present per cubic foot of air. The moisture content which passed through the furnace was approximately 40 gallons of water per hour, and at times this was increased to over 300 gallons.

This synopsis of exact conditions as existing in one special development will show the great importance and possible efficiency of the process in many other applications. The fact that the air is cooled from 80 degrees F. to 28 degrees F. during this process, and that this remarkable efficiency can be shown, is a matter for much further surprise and speculation. Dehydrated air is absolutely necessary in the cotton industry, in tobacco warehouses and in tobacco manufacture in general, in very many of the great storage developments, and, as is shown above, its practical application in the metallurgical industries results in a remarkable increase in efficiency. Further, to-day air is used for producing cold water by the absorption of vapour from water immediately in contact with it, with the consequent cooling of the water due to the absorption of the latent heat of evaporization required for this operation. Cooling towers, so called, are extremely common in many refrigeration installations, since cold water is absolutely necessary for the operation of the condenser. In fact, wherever condensers operate, if of the open-type variety, they are much increased in efficiency by satisfactory dehydration of the air and the consequent further cooling of the water. A remarkable condition holds in regard to this special development, namely, that warm, dry air has a much greater cooling effect, due to its absorptive power, than cold, moist air used under similar conditions. Of course, limitations exist in both developments, but at a maximum much higher than the average engineer would be inclined to assume.

Now the moisture content of the air is a very variable quantity. It varies with locality and with its contiguity to a large body of water. Temperature variations affect its value very greatly, and it is very variable with weather conditions generally. The relative humidity is defined as the ratio of the quantity of moisture that the air holds per given unit at a given temperature to the quantity that it could hold at that temperature without condensation. The water content of air will vary 300 per cent. between limitations as represented by February and June conditions without much variation in relative humidity.

Now this moisture can be removed by any of a large number of chemical agents known as dehydrating compounds. Sulphuric acid and calcium chloride are the chief and most active of these, and formerly air was dried very satisfactorily by being blown through drums filled with calcium chloride or allowed to bubble through tanks containing sulphuric acid. For some reason or other, probably on account of the difficulty of handling the chemical, if calcium chloride, and the deteriorating effect of sulphuric acid on the retaining vessel and the machinery in general, this development has not been general in its utilization. In special applications, such as physical and chemical laboratories, where dry air is often a necessity, in the production of liquid air as a commercial process, and in a number of other minor developments, these processes have been developed and are fairly efficient. Undoubtedly the special

development in the blast furnace, whereby dehydration is accomplished through refrigeration, owes a very great degree of its efficiency to the increased density of the air, as well as to the removal of the moisture content. Air kept at constant pressure and cooled decreases in density in direct proportion to its absolute temperature fall, and it can be readily assumed that this development in iron-furnace operation will be much extended, with further increase in efficiency, if further cooling can be accomplished without undue loss in the efficiency of that process. In this development it is undoubtedly the cumulative effect of these two effects which results in the remarkable increase in efficiency as shown. Now air, as a general dehydrating agent, will not come into general use in every development, since it possesses a strong competitor in the utilization of superheated exhaust steam for the performance of this duty. Many woolen and textile mills dry their fabric by this application, with very satisfactory results. It is more efficient and more readily available than dry air, on account of its higher temperature and large water absorptive power, since the total moisture content increases rapidly with rise in temperature, and the tendency of all such materials is to become saturated on contact with water.

The actual development for the compression of air for any purposes by this process is but at its inception. While undoubtedly blast furnaces could probably remove the water content of the air by means of any of the dehydrating agents, and do it even more efficiently, when the cost of refrigerating machinery is considered, this application is by no means limited in its further development. A number of continuous dehydrating machines utilizing sulphuric acid or calcium chloride have been developed to-day, notably that used in the production of ice by means of the vacuum process, whereby water is made to freeze itself by the rapid evaporation in a vacuum from its surface, with the further absorption by sulphuric acid of the vapour as fast as produced. In this plant the sulphuric acid is carried in a closed cycle continuously in a very efficient process, and the further application of this development for the removal of the moisture from the blast in iron-furnace operation would be very efficient and could be accomplished with minimum first cost in installation of plant. The real application of mechanical refrigeration in this development is undoubtedly the compression of the air with increased efficiency through the increase in density both on account of the removal of water vapour and on account of lowering of initial temperature of compression. Again, the compression itself is accomplished much more effectively with high air density and low initial temperature, since, if accomplished adiabatically, the final exhaust temperature is much diminished, and the mean operating pressure diminished with a further partial elimination of the more inefficient portion of the stroke. That this development will extend to the preparation of air for compression before its production by means of the air compressor is a foregone conclusion, and the efficiency of the process can scarcely be conjectured, since many of the data for such calculation are not at hand. However, it must be borne in mind that this problem—namely, that of variation of density and temperature of air—is always present with dehydration, however accomplished. The extent to which the moisture present is objectionable can be readily seen from the foregone example, and undoubtedly many future possibilities are offered for this development. In all vacuum stills where the distillation is accomplished at temperatures lower than those existing under normal atmospheric pressure, this development presents possibilities. In sugar refineries, where the syrup is boiled down at diminished temperature by

a maintenance of a vacuum; in condensed milk factories, in oil refineries, and, in fact, wherever distillation occurs under these abnormal conditions, the same result—that of dehydration of this material—can be accomplished readily by blowing dehydrated air through the mixture. Of course, sulphuric acid can be substituted for the absorption of the moisture whenever practicable; but under the example cited its ultimate removal is almost impossible, and it often has a very injurious effect on the finished product.

In a general way, it can be stated that the problem of air dehydration possesses manifold applications. The utilization of refrigeration for the actual dehydration in a number of specific developments will have the sole result ultimately of bringing this problem to the attention of the average engineer, since in all probability the results obtained, while accomplished with remarkable efficiency by mechanical refrigeration, can undoubtedly be successfully attained by much more efficient processes of dehydration.

# THE DEVELOPMENT OF SUBMARINE SIGNALLING

By Robert G. Skerrett

ONLY within the last few years has submarine signalling by means of sound become a system in the true sense of the term. Thanks to the enterprise of certain Americans, after years of baffling investigation and some hazards, success was won and a practicable and efficient apparatus evolved by means of which signals could be sent and received by sound waves transmitted under water.

These latter-day inventions have added greatly to navigational precision both in times of fog or stormy weather, and it is now possible to approach a difficult channel or to shun a dangerous position with a degree of satisfying certainty not probable a few years ago. This article, however, is not intended to describe the details of these truly epoch-making American inventions; its purpose is to show how rapid have been the advances made in this science of summarine signalling, and to point to some of the ways by which Mr. Gardner, an English engineer and inventor, has widened the useful application of the basic principle involved while adding to an astonishing degree to the precision of control.

That water is a better conductor of sound waves than air was suspected a long while ago, but it was not until the classical experiments made by Colladon and Sturm on the Lake of Geneva in 1826 that the fact became a matter of scientific record. At that time a bell, hung 3 feet below the surface of the water, when struck by a hammer, could be heard at a distance of 9 miles—about four times as far as the sound was carried when the bell was struck in the air. Of course, the greater and uniform density of the water was the primary cause of the phenomenon, while the absence of geographical "accidents," such as hills and valleys, forests and variable conditions of atmosphere, etc., acted to make water the better medium for the transmission of sound waves.

With this fact established, it seems remarkable that subsequent investigations accomplished no substantial results until within the last decade; and, just as wireless telegraphy and wireless control above water have introduced revolutionary methods of aerial communication and means of distant mechanical direction, so have sound waves under water opened up an immense and fascinating field to the inventor bent upon evolving various applications for this new-born subaqueous wireless system.

Two or three years ago Mr. John Gardner invented a dirigible torpedo, the various functions of which were controlled by Hertzian waves. The torpedo performed in a most satisfactory manner; but, like all other apparatus subject to such electrical impulses, it was liable to interference through the agency of other Hertzian waves set up either by accident or by intent, and while his torpedo proved less sensitively responsive in this particular than most other inventions of the kind, still the weakness or fallibility was there in a measure. It was to overcome this failing that Mr. Gardner sought some other means by which to send out the controlling impulses; and, after some study, his mind went back to those sound experiments on the Lake of Geneva in the early part of the last century. At once he realized that, by using sound so transmitted, he could not only get below the water and out of the reach of interfering Hertzian waves, but he saw that he

could count upon more regularity of results, because he would not be contending with variable atmospheric conditions. It was not all plain sailing, however, because another difficulty immediately appeared: the maritime use of submarine sound-signals for navigational warnings threatened to upset this plan, while the sound of the churning screws of moving steamers also seemed to imperil the scheme.

These seemingly insuperable difficulties were overcome by the adoption of musical tones of definite pitches as a basis for the system. At once the effects of all undesirable sounds were blocked, and it was made certain that neither mistake nor intent could cause interference or undesired action.

Each note of the musical scale has its own distinctive individuality, and the index of that character is the number of vibrations per second necessary to produce that tone. By making the receiving instrument sensitive only to a chosen note, or group of notes, of fixed duration and interval, and deaf or mute to all others, Mr. Gardner was able not only to insure immunity from interference, but was able to add precision to all uses of the apparatus, whether in the form of a receiver of sound signals or as an agency for the reception of impulses designed for the distant control of certain mechanical movements.

The listening ear, with its personal equation of variable keenness, is entirely superseded in Mr. Gardner's invention by an automatic visual register of the approach to the zone of sound, as well as the direction in which the source of that sound lies. In this particular Mr. Gardner is able to place every member of a ship's navigational force upon the same basis of efficiency, whether one ear be as keen as the other or whether the hearing of one member of the staff be more acute than that of the rest of them. In this particular alone the Gardner apparatus is a very distinct advance in the direction of the use for submarine sound signals as an aid to navigation. The apparatus can be arranged either to sound a warning bell on shipboard or blow the whistle automatically of the steamer, and thus, despite any opinion to the contrary on the part of the navigator, due warning may be given of the vessel's actual presence within the danger or warning zone.

Let us see how these remarkable results are effected, and then we can appreciate the wonderful simplicity of the whole invention, which has for its initial object merely the governance of an electric circuit, which, in turn, controls a number of mechanical movements.

At the sound-receiving station the essential apparatus consists of a vibrator sufficiently sensitive to respond to the faintest impulse of the proper sound waves. This vibrator or resonator, whichever one chooses to call it, is fundamentally a strip of very thin metallic tape so attached to the inside of a vessel's bottom plating that it may receive readily all the vibrations imparted to that portion of the ship's skin exposed to the submarine sound waves. In this manner the tape vibrates sympathetically to all the impulses reaching the craft's submerged plating; but, being tuned to a definite note, the required magnitude or amplification of these responsive vibrations takes place only upon the arrival of the right tone, at which time the tape starts the electrical action upon which depends all further effects at the receiving station.

The movements of the steel tape are so small, even at the required amplification, that no change is perceptible under a strong magnifying glass; and where one one-thousandth of an inch is considered a fine adjustment for telegraphic relays, still, in the case of the Gardner instrument, a still more exquisite adjustment is necessary to regulate the carbon contacts of the microphone, which regulates the opening and

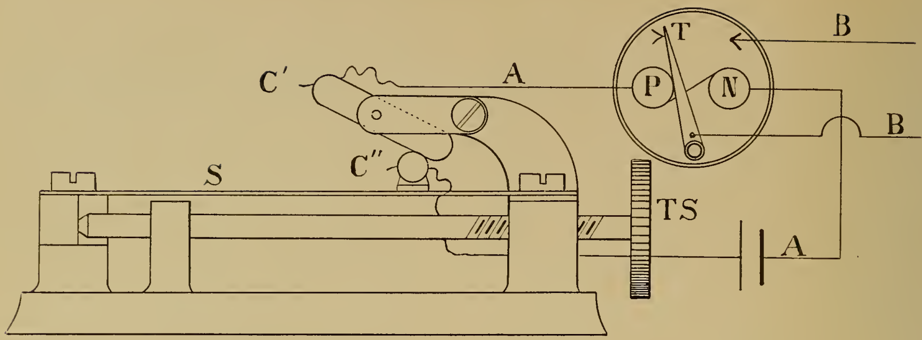



DIAGRAM OF RECEIVING INSTRUMENT

closing of the electric circuit. To meet the requirements of such minute movements, none of the usual methods for adjusting contacts being suitable, a carbon-pencil microphone is mounted upon the resonant tape. This microphone consists of two carbon contacts, the upper and larger carbon pencil being of such weight and dimensions that it will vibrate in unison with the tape upon the arrival of any note not corresponding to the natural period to which the vibrator is tuned, but which will remain relatively stationary, as compared with the tape, when the latter is vibrated responsively to the proper note, at which time contact between the two carbons is imperfect, thereby increasing their electrical resistance and reducing the amount of current which can pass through them. This is the key of the whole operation. As Mr. Gardner better expresses it:

"With silence, or with an unsuitable note, the pressure of the pencil is, therefore, constant; but upon the arrival of a sound in agreement with the pitch of the vibrator, amplification follows, and the intimacy of contact between pencil and vibrator are diminished."

To make these operations still plainer, let us return to the diagrams of the instrument. In Fig. 1 *S* is a steel or metallic ribbon or vibrator, which may be tuned to a variety of pitches by means of the tension screw *TS*. *C'* is one of the carbon contacts of the microphone, and is so placed upon the vibrator *S* that it can properly partake of the latter's movements. The second carbon pencil of the microphone *C''* is pivoted in the fork of an overhanging frame and mounted eccentrically, so that its lower and heavier end will bear against carbon pencil *C'*. Carbon pencil *C''* is of sufficient weight to retain close contact against *C'* when the metallic resonator is adjusted by any sound or vibration other than that to which the strip is keyed. So long as this contact continues the current through the circuit *A* flows undiminished and the tongue or index *T* of the relay retains its position at *P*. But when the proper sound arrives and the resistance at the contacts is increased, the proper measure of current does not flow through *C'* and *C''* to maintain the electrical balance, and the tongue *T* is drawn over to the stronger pole *N*. When the tongue *T* touches the pole *N*, this movement completes the local or relay circuit *B*, and the desired mechanical operation is set in motion by the force of this local source of electrical direction. By the use of a step-by-step action, after the circuit *B* has been closed, various mechanical functions can be successively controlled, the right sound, or group of sounds, having been made in order to start the initial movement of the relay tongue *T*.

A tuned string, wire or strip, when sounding its proper note, vibrates in a succession of waves or "loops,"

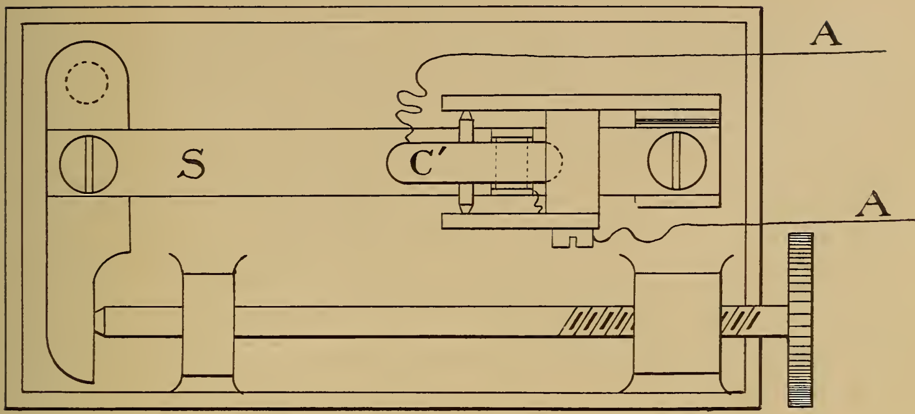



FIG. 2.—ARRANGEMENT OF SINGLE-TONE INSTRUMENT

which intercept one another in the manner shown in Fig. 4; and the points where these movements cross —*N*, *N*, *N*—are called nodes, while the amplification or waves—*L*, *L*, *L*— are called "loops." The nodes are spots of least motion. It is found that, by mounting the carbon *C′* at or near one of these nodes, the free vibration of the steel tape or resonator *S* is not dampened or suppressed; and, therefore, the current reduction or resistance at the carbon contacts of the microphone is really much greater than when the carbon *C′* is placed near a loop where the greatest movement is. As a result, an undesirable sound is less likely to produce the disturbance necessary to upset the electrical balance by which the relay tongue *T* is shifted to the pole *N* and the relay current *B* brought into play which controls the ultimate action.

Mr. Gardner says: "This apparently trifling detail is actually one of great importance, giving, as stated, sensitiveness to the desired sound and insensitiveness to improper ones; and it is hardly too much to say that the system has been rendered practicable by its adoption, coupled with the peculiar position of the carbon pencil *C′* in relation to the strip."

In Fig. 2 we have a plain view of a single-tone instrument, and in Fig. 3 is shown the arrangement of a three-tone instrument, which requires the simultaneous sounding of all three notes to secure the release of the relay tongue before the desired operation which follows can take place. This multi-note form of the apparatus would be especially valuable in naval or military operations,

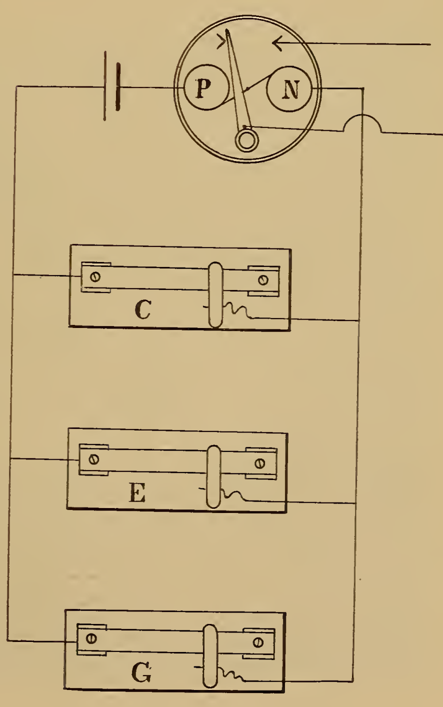



FIG. 3.—THREE-TONE INSTRUMENT

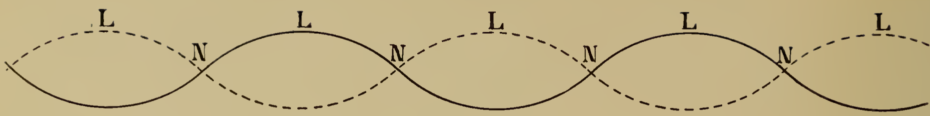



FIG. 4.—INTERCEPTING WAVES OR LOOPS

where the prime aim is secrecy and the prevention of "interference" on the part of an enemy. These several strips or resonators can be tuned to any one of a large range of possible tonic combinations, and these changes can be effected rapidly and in a manner to deceive the foe.

As an aid to navigation, one of these receiving resonators would be placed below the waterline and on each side of the vessel's bow, and, by introducing an electrical resistance, a dial would be arranged so as to show on which side the disturbance or sound was greatest, and thus indicate automatically and visually the direction of the signal's source. Again, when the index ceased to register, the observer would know that the ship had passed beyond the warning zone.

By the adoption of a telegraphic recording instrument and the use of a dot-and-dash code, it would be possible to transmit signals by this wireless method and to have a record of them, so as to avoid the possibility of mistaken interpretation. In this way, a surface vessel could keep in touch with submarines lying entirely submerged, and in this particular a distinct advance would be gained over the present use of aerial wireless as now adopted in some of the foreign services for this purpose.

This system has already been adapted to the control of a wireless submarine, and in his laboratory Mr. Gardner has a model representing

FIG. 5.—THE GARDNER WIRELESS-CONTROLLED SUBMARINE

the various movements involved in propelling and steering such a craft and also the expulsion of a torpedo. These functions are controlled by the voice, and when the orders are given in the proper tone the apparatus responds with uncanny promptness to these commands. A further use of the system is that of possibly controlling the detonation of submarine mines, the various groups being made responsive to certain musical notes, or succession of notes. This not only adds to the passiveness of the mine in the presence of friendly vessels, but it makes it more deadly certain in the presence of a foe, while simplifying the whole installation by doing away with much of the expense and the complications associated with the usual mine cables and their troublesome and uncertain connections. Further, this system of sound control can be adapted to the turning on and off of the lights in gas-illuminated channel buoys, and there is an endless list of possible uses to which this invention may be put. The scope of its application is limited only by the range of sound of the directive signal generator; but Mr. Gardner has in mind a very powerful sounding apparatus by which he expects to exercise control over a distance of many miles, and there seems to be no reason why he should not succeed in this important development.

# THE MINERS' EIGHT HOURS QUESTION

ITS RELATION TO BRITISH INDUSTRY

By T. Good

IT is questionable whether the iron, steel and other manufacturing industries of Great Britain have ever been faced with such a grave menace to their welfare as confronts them just now in the shape of a mines eight hours bill. This may seem a strong statement, but it is warranted, for a comparatively small restriction of the output of coal is more than probable to result in a substantial and permanent increase of price—a matter of the utmost importance to a nation depending so largely upon manufactures as the British do. If this bill is permitted to become an act, it will result in the abandonment of the least profitable mines and in enhancing the cost of operating all the others. Large quantities of coal in thin and uneven seams will be lost, the output from the thick seams will be cut down, and the market price of this important material of industry will be forced up by not a trifle. Can the British nation afford to have its industries handicapped in this manner?

Now that the question of a hard-and-fast eight-hour working day in the coal mining industry, regardless of the widely varying circumstances of the different districts, mines and seams, appears to have passed the academic stage and to have come within measurable distance of the point of legal enactment, it is imperative that the issues involved should be fully and fearlessly discussed. This is no party political question, nor shall we offer to approach it as such; indeed, politicians of all shades of opinion have promised to support this particular measure; but it is a matter of vital national concern — a problem which must affect the whole course of Britain's industrial future, and, as such, it demands the strictest possible attention.

In the first place, we may ask what justification there is for State interference of this kind? There are only two grounds upon which such a measure can be justified: the first, that it would prevent excessive hours of labour in an unhealthy occupation after all voluntary efforts to remedy such a grievance had failed; and the second, that it would promote safety. But this bill has neither of those objects in view. Excessive hours of labour do not prevail in the coal-mining industry, and if they did the miners' union is fully competent to reduce them by the ordinary methods of negotiation with the mine owners. The hours of labour of the British coal miner are already much shorter, and his hours of leisure much longer, than those of any other workman in the country; therefore, so far as hours are concerned, there is no case for this bill—a bill to remedy a grievance which does not exist.

And so far from this measure promoting safety, it is more than probable that it would have the very opposite effect. If the measure is enacted, a few at least of the workmen will "rush" more than hitherto, and in a few cases the mine managers will "speed up" the haulage and windage, with increased danger as the inevitable result. It is not inconceivable to those closely acquainted with working conditions that, under this measure, accidents in British coal mines would become as frequent as they are in the United States. Indeed, they might become more frequent, for the coal mines of Great Britain are far more difficult to work than are those across the Atlantic. Not only is it quite impossible to say one word in defence or justification of this bill, even the Minister in charge of the bill does not so much as make an attempt to justify it; but there is a positive plethora of reasons to be urged in opposition to it. On humanitarian as well as commercial grounds this bill can be condemned.

The departmental committee appointed to inquire into the probable economic effects of this bill found that "the average time from bank to bank on a day of full work is nine hours and three minutes." The average working day in other occupations, including meals, is eleven hours, yet it is proposed to cut down the working day in the very industry where it is already exceptionally short. This committee reported that, "making allowance for 'stop' and 'short' days, the average theoretical full week's work amounts to 49 hours 53 minutes," but that "the hours actually worked by the men are 13.36 per cent. less than their theoretical full time." The full week's work, including meals, in other industries is 61 hours, with liberal doses of overtime in case of pressure. Where, then, is the justice of an eight-hour law applied to miners only? If an eight-hour day, including meals, for the miner, why not for the sailor, the stoker, the fisherman, the docker, the forgeman, the iron-puddler, the steel-smelter, the chemical-worker, and others? And what about the female chain-makers and bolt-workers, women and girls, fathers and future mothers of the race, sweating and slaving in the forges some twenty hours a week longer than the miners work?

Nor is the miner's work exceptionally unhealthy. A good many years ago it was proved by an eminent authority, Dr. Ogle, that, "excluding accidents which shorten, when they do not destroy, life, the miner's occupation is not one that is responsible for a high mortality rate. Out of forty occupations the miners' stood twenty-first on the list of the comparative mortality tables." Since then the miner's occupation has been much improved. The departmental committee report that "the health and physique of the coal miners at the present time compare favourably with that of any other class of work-people." This notwithstanding the fact that British miners, as a class, indulge in certain excesses which need not be named more than do other workers with less leisure.

There is no justification for this bill. British miners are the very best-paid workmen in the country in proportion to their skill, and their working hours are already much shorter than those prevailing in any other occupation. Nor is their work now exceptionally dangerous. The coal mines of Britain, in proportion to tonnage raised and in proportion to numbers employed, are more than three times as safe as they were half a century ago, and, in proportion to tonnage raised, are safer to-day than are those of any other important country. One of the effects of this measure would be to dislodge Great Britain from the proud position she has attained in the matter of safe working.

All the Mines Regulation Acts which have been passed in Great Britain hitherto have been designed

for the promotion of safety, or for the protection of women and children; but this is not a bill for the promotion of safety, or for the protection of defenceless workers, but a measure to cut down by law the working hours of grown and free men, and to curtail the supply and increase the price of coal, to the detriment of the nation at large.

Since 1848 State interference in the mining industry has increased the cost of coal by fully 2 shillings per ton.* Two shillings per ton of coal now raised in England means £25,-000,000 a year. No one complains, because, as just mentioned, State interference has usually been in the interests of safety; but now we are invited, not to add further to cost of production for the promotion of safety, or for the purpose of removing any grievance, but to curtail production itself without any possible increase of safety, but with a highly probable increase of danger.

Parliament and the nation would do well to ponder seriously the probable cost and effects of this bill; it is a highly dangerous departure in State control. We say frankly and sincerely that the government has adopted this bill, that gentlemen on both sides of the House of Commons have supported the measure, and that what is termed "public opinion" has acquiesced in the matter being brought within range of practical politics under misapprehension. As a matter of fact, public opinion (and Parliamentary opinion) has been misled concerning the mining industry. If the real conditions of the coal mining industry had been understood this eight hours bill would never have come anywhere near the point of legal enactment. If Parliament fully understood the serious nature of the measure there would be no danger of its passage into law. If the nation, whose welfare so largely depends upon cheap coal, can be made to understand the real meaning of this bill, it will not be permitted to become an act.

This bill is the direct result of misconception on the part of the general public on the one hand, and unjustifiable pressure and agitation on the part of a small, but noisy, faction on the other. As evidence of the misconception that exists regarding this occupation, we may mention that, a few years ago, a writer of considerable standing declared that "the miner went into the bowels of the earth, and, with infinite toil and danger, raised a ton of coal for 10*d*, or even 8*d*." That statement was quoted over and over again in public, along with highly-coloured accounts of the enormous profits made by mine owners. Yet at that time the actual wages paid to the miners of this country exceeded 4 shillings per ton of coal raised! But the public generally swallowed the lie. Still more recently, a leading socialist journal, "The Clarion," published a special article on the coal trade, in which it was solemnly stated that "the average wage of the miner is less than 2 shillings per ton of coal raised." That statement has been quoted in the press, repeated by a thousand street-corner agitators, and is being advertised up and down the country at the present moment. What are the facts?

The average annual per-capita output of coal in Great Britain is considerably below 300 tons, so that if the miner gets less than 2 shillings per ton, he gets considerably less than 600 shillings in a whole year; in other words, he does not get more than 10 shillings a week the year round. This is a sample of the misrepresentation, not to say mendacity, upon which modern labour movements in general, and miners' movements in particular, are conducted. As a matter of hard, indisputable fact, the miners get, at the very least, three times as much as the labour leaders and socialist agitators who are running the eight-hours movement seek to make out. The cost of raising coal in Great Britain at the

* See CASSIER'S MAGAZINE, July, 1907.

present moment, in labour alone, apart from cost of plant, equipment and appliances, is not less than 6 shillings per ton.

The public has been continually fed on a diet of exaggerated accounts of the coal trade. On the one hand, it has been presented with graphic pictures of miners delving at a hazardous task for a mere pittance of a wage; while on the other hand, it has been given highly-coloured stories of mine owners growing rich beyond the dreams of avarice. So long and so persistently have the conditions of the mining industry been misrepresented by paid agitators that the great mass of the electorate and the majority of the members of Parliament are prepared to vote for anything to check the remorseless tyranny to which the miner is supposed to be subjected!

Coal mining is the very last industry, and not the first, to which a law of this kind should be applied, for two reasons: first, because the natural conditions vary so much, not merely between the different districts, but between the seams and the mines in the same districts; and the second, because the miner already enjoys a more privileged industrial position than any other workman in the country. The State has already done more for the underground worker than for any other, and, apart from State interference on his behalf, the miner has an exceptionally high wage and an exceptionally short working day. And not only is this the last industry, but Great Britain is the last country in which the mining industry should be subjected to a regulation of this description, for the simple reason that British mines having been longer exploited, our thickest and best seams of coal are more nearly exhausted than is the case elsewhere.

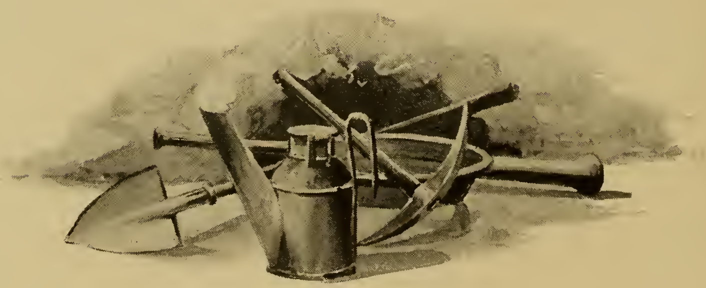
We seriously suggest that Parliament will commit a grave blunder if it passes this bill. We are certain that Parliament will not pass the bill except under misapprehension. Those interested must endeavour to remove that misapprehension. The miners' leaders are seeking to persuade Parliament that the effects of the measure will be trivial, and they point to the fact that predictions made concerning past measures of labour legislation have been falsified by experience, that the measures have not proved so costly as the opponents of State interference have calculated. But against this contention we may point out that on some occasions labour legislation has proved far more costly than anticipated, and, further, that this particular measure is of an unusual character. The Workmen's Compensation Bill of 1897 proved to be a burden between 300 and 400 per cent. heavier than was originally estimated by the very best experts, and not only did it prove costly to capital, but it inflicted many hardships upon labour.* This eight hours bill is not an ordinary measure of labour legislation as hitherto understood; it is not for the protection of the worker from danger; it is a measure for the compulsory restriction of output of a prime essential of productive industrialism. We might as well restrict the output of our farms as of our mines. This bill seeks to set at defiance the fluctuations, exigencies and necessities of industry. Why not set the seasons at defiance?

Restriction of output by trade-unionists has invariably been condemned by right-thinking men of all parties and classes, even by trade-unionism leaders. Now it is proposed to restrict output by act of Parliament. It appears that that which is a vice, an industrial handicap and a menace to the commonweal, when practiced by a few mistaken workmen, becomes a virtue and a national necessity to be enforced by law when backed by the organized votes of less than one-tenth of the electorate! The community is to be sacrificed to placate the clamour of a faction, simply because the faction

* See Cassier's Magazine, July, 1907.

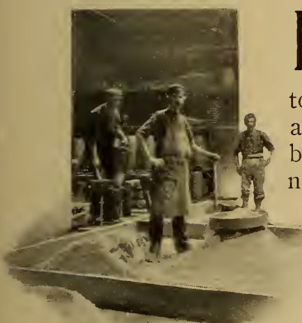
wields electoral power in a few constituencies. If this bill is passed it will glorify the paid agitator, and set a huge premium on sectional movements of a dangerous character. If a legal enactment eight-hour day is granted the miner—a workman who is already exceptionally well treated in the matter of hours, who is well paid, highly organized and fully competent to look after his own interests—how can a similar concession be withheld from other classes of workers.

This measure, if enacted, will send up the price of coal. The probable increase of price must not be measured by the probable decrease of production alone, nor by the probable increased cost of production alone. Not only will the price of coal move upward in sympathy with the actual rise in the cost of production, but it will mount higher still through restriction of output. Both these factors—increased cost of production and diminution of production—must be taken into account. The first of these will result in a substantial and permanent increase of price; the second will cause a further material increase on top of that, due to increased cost of production in ordinary times, while in time of pressure the rise in price will be altogether out of proportion to the cost of production and the restriction of output combined. How this will affect the iron and steel industries, in which so many tons of coal are used in the production of a single ton of finished goods, we need not seek to demonstrate. We ask, can the British nation afford it?



# MODERN METHODS OF CASE-HARDENING

By J. F. Springer

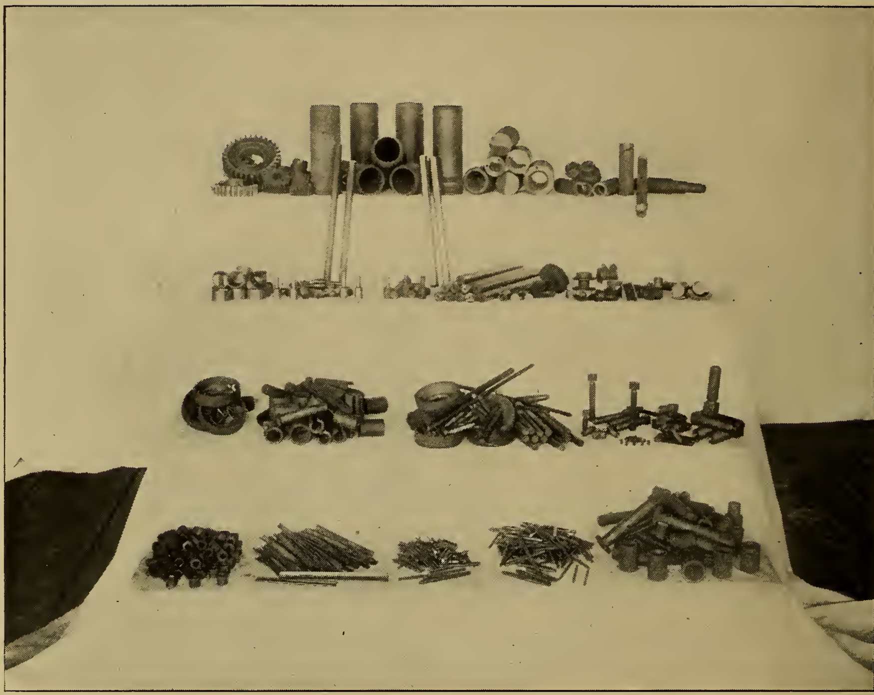


PERHAPS the noblest of all metals is tool-steel. There is a wonderful combination of stiffness, hardness and elasticity that go to make it an ideal material for a great multitude of exacting uses. There are, however, two factors which serve to prohibit its employment for many purposes where no doubt it is the very best possible material. These are reasons of expense. First, there is the excessive first cost of the raw material. Machine steel may be bought for 3 cents per pound, while a good quality of tool-steel is worth anywhere from 12 to 18 cents. In addition to this multiplication of expense by 4, 5 or 6, there is the additional excessive cost of machining. It is, perhaps, not too much to say that this latter doubles or trebles the expense of the machine operations with mild steel.

In consequence of these prohibitive costs, manufacturers have sought to substitute, wherever practicable—and, in some cases, where it ought not to have been attempted—case-hardened machine-steel parts. These pieces, when finished, were really of two materials—a central portion consisting of the original mild steel and an exterior skin of tool-steel. For many purposes such parts are quite as good as tool-steel parts would be. Indeed, in some cases they are even better. Thus, if the hardness of the exterior is the chief requisite, and no serious demand is made for capability to remain rigid under severe stress, then a case-hardened piece will usually answer. For it can be produced with all the hardness of a tool-steel part. It sometimes happens that a hard surface combined with a tough interior is required. In some of these cases mild steel, case-hardened, is to be preferred.

However, the proper extension of case-hardening has been limited by two main considerations. First, the process, as at present practiced, is often unreliable in its results, unless in quite skillful hands. There are so many factors, some of them beyond an easily exercised control, that a simple procedure, certain to pioduce satisfactory results, seems practically out of the question. The very fact that so many different formuias are, and have been, in vogue, tends to show that the real controlling factors are not well understood.

As usually practiced, case-hardening of iron or mild steel consists in surrounding the piece with a packing consisting of some material capable of supplying carbon, and then suitably heating the whole to a temperature of, say, 1,500 degrees, when the metal opens its pores, as it were, and absorbs carbon from the surrounding material. The method of accomplishing this result is usually to make use of a cast-iron or wrought-iron box or case. The article, or articles, are packed in this with a suitable carbonaceous material. Upon this point a great divergence of opinion has arisen. Some use raw bone, some charred bone; some use leather scraps, while others use leather charcoal, while still others



EXAMPLES OF CASE-HARDENED MACHINE PARTS

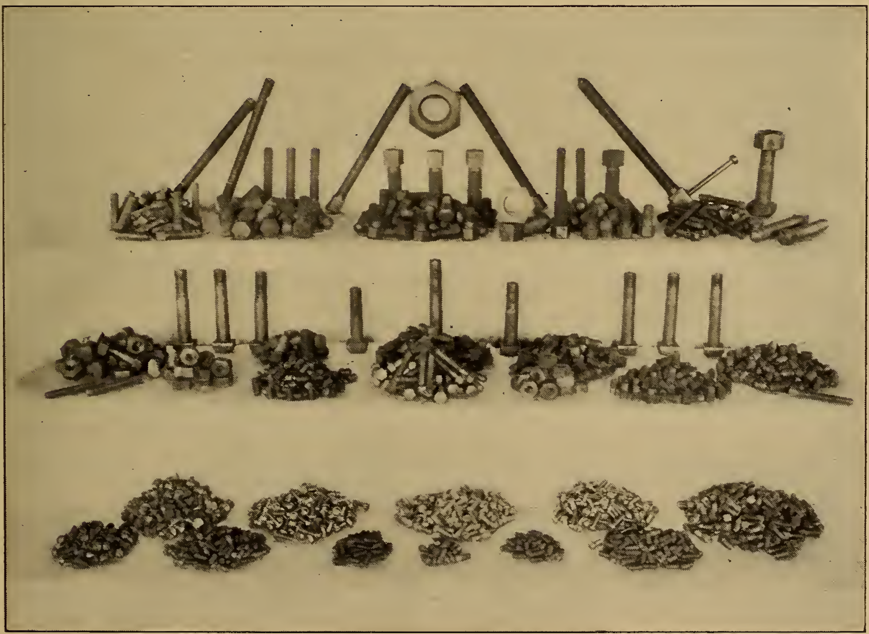
use wood charcoal. Still others employ a combination, and some use one packing for certain work and another for different work. But we will suppose the articles packed. The case is then covered and sealed, say, with clay, to make it air-tight, and then placed in a furnace and heated to the proper temperature. That is to say, it is heated until the proper temperature is supposed to be reached. The usual method of determining the temperature is by the use of testing rods. That is, rods or wires are inserted which may be taken out at any stage. These enable the operator to know something of the interior heat of the case, much as a cook judges of what is going on upon the inside of the cake by means of broom-straws. Having attained the heat desired, it is maintained until the desired impregnation of carbon has been obtained. Extended lengths of time have seemed desirable for this, if a particularly thick skin of tool-steel were desired. Thus, heatings prolonged to 18, 24 and even 48 hours have been employed. And when it was done, who knew whether success had been attained or not? If the piece was broken something could be learned for that particular piece, but not necessarily for its neighbour. The method reminds one of the boy who was admonished by his mother to be sure and bring home good matches. His only method was to strike them, one by one, to see.

Of course, the work could not absorb any more carbon than the packing contained. When this point was reached a continuance in the furnace produced no further carbonization. It might deepen it, but only at the expense of the exterior, for a furnace has no creative ability to produce carbon. However, two methods—and both of them, for different reasons, objectionable—may be employed to increase the depth of carbonization without detriment to the degrees attained at the surface. The one method is to withdraw the case

and repack with a fresh supply of carbonaceous material. But consider the expense, especially if the operation is necessary a number of times. If the work needs to be uniformly carbonized, this packing and repacking can scarcely be left to unskilled hands. In fact, if one wishes the best results, he will be careful that no piece of the work touches another piece, and that none of the work touches the sides of the case, being careful that each and every article is surrounded with a carbon supply. Then he will be careful not to pack tightly here and loosely there, but endeavor to secure uniformity. All this requires time, and the time of a skilled labourer. Every repetition, of course, adds to the expense. This method, however, will produce good results. The second method is to use increased quantities of packing, surrounding each article with a thicker layer of bone or other material. But this cannot always be depended upon to be effective. The layer next an article is first exhausted. The layers beyond must then succeed in transmitting their carbon through the intervening layers. And it would appear as if an exhausted layer operates not only in interposing an obstacle, but also in absorbing carbon. At any rate, it would seem that increasing the packing has its limitations.

Consider, in either case, the loss of heat in raising the packing to the high heat necessary. In the case of repacking this has to be done again.

If we consider the matter of quality, we shall find that pack-hardening is hardly to be regarded as absolutely reliable. Thus, on account of differences in chemical constitution of the packing, it is not to be expected that the amounts of carbon delivered at all points is the same nor under equal pressure. Taking into account the inevitable inequality in thickness of the surrounding carbonaceous material, it can readily be seen that this method is not to be depended on for uniformity in carbonization. Further, when we reflect that carbonization



BOLTS AND SMALL PARTS CASE-HARDENED AFTER MACHINING

MISCELLANEOUS CASE-HARDENED PRODUCTS

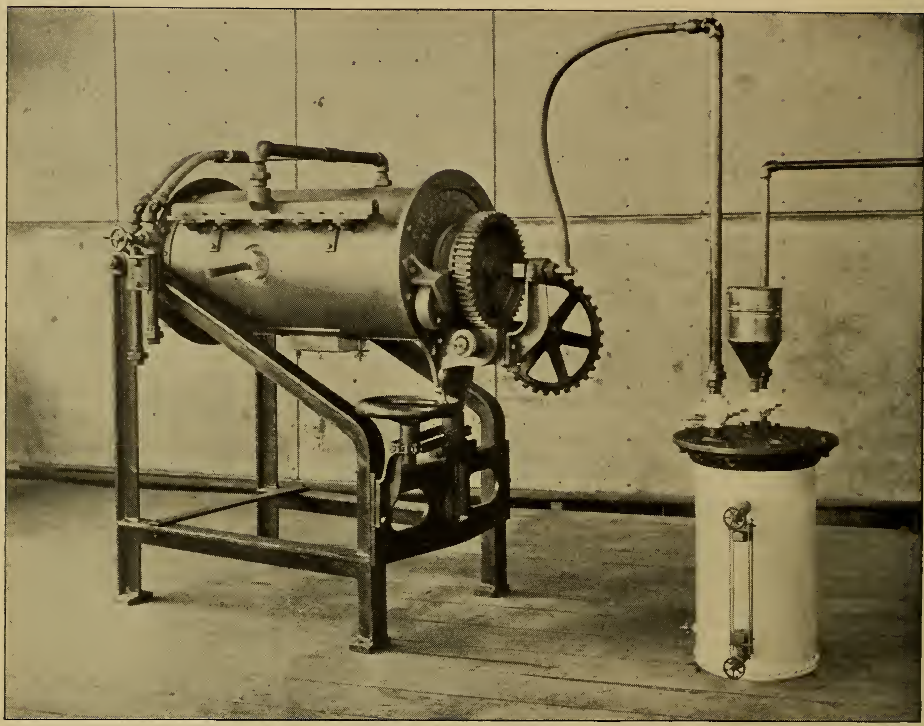
begins at different points within the case at different times, owing to inequality of temperature, we can easily see that we have here an additional reason operating against uniformity throughout the case.

At first sight, it may not be evident why uniformity is important. Remembering, however, that the contraction consequent upon the cold plunge at the moment of hardening differs for different degrees of carbonization, we can see that considerable distortion would follow, one part of a piece contrasting differently from another part. To allow for this in pieces that are to be ground means expense in grinding.

A new process, recently invented by Mr. Adolph W. Machlet, strikes at the root of most of the difficulties. This method dispenses with packing altogether, unless, indeed, we regard the work surrounded by gas as packed in gas. In this process there is introduced to the heated work a carbon-laden gas. From this gas the articles absorb carbon. Everywhere there is the same pressure, whether it be a small, threaded hole or some more prominent surface. As the carbon is absorbed by the metal fresh gas is admitted, while the old passes off. No repacking, with its expense for labour and heat and delay, is required, the process being continuous, effective in results, and economical of time and money. The container is continually rotated, which imparts a motion to the work itself. By this means the gas is circulated, which fact tends to improve still further the uniformity of the resulting carbonization.

A further matter, and one to which attention is here directed, perhaps for the first time, is the fact that this method permits the operation of the process under pressure. This would seem to have possibilities within it. For thus it may be that carbonizations which now require a series of hours may ultimately be found possible of accomplishment in minutes. But in working along on this line it may be well to go slow, for gas under considerable pressures in a red-hot retort, whose walls are softened thus by heat, presents a generation not to be dealt with recklessly.

A BATTERY OF CARBONIZING MACHINES, FRONT VIEW, SHOWING CASE-HARDENING RETORTS AND HEATING CYLINDERS



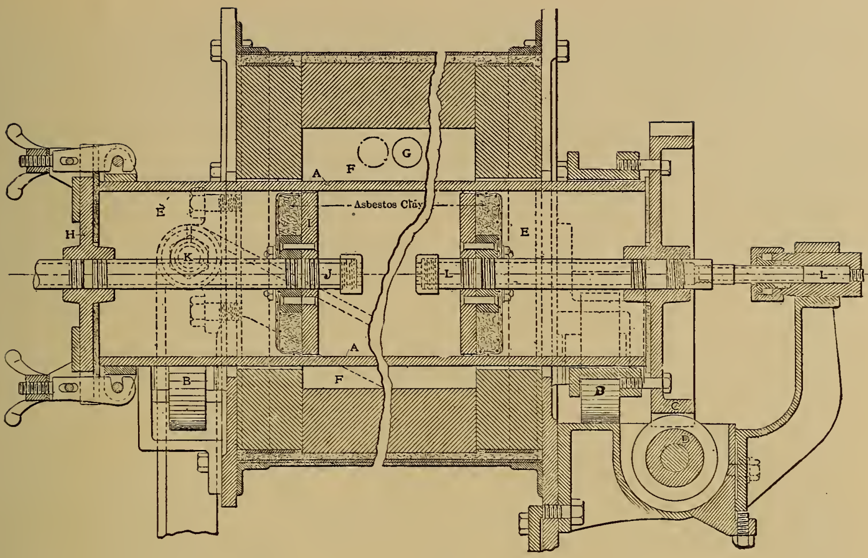
REAR VIEW OF CARBONIZING MACHINE, SHOWING CASE-HARDENING CYLINDER, REVOLVING AND TILTING MECHANISM AND GAS GENERATOR

The gas used to afford the carbon supply is a special product, produced in a generator specially designed for the purpose. No heat is applied, the process being purely a chemical one. A carbon vapour obtained from an oil is mixed with a neutral gas. It is supposed that the atoms or molecules of carbon are held in suspension in this gas until the moment of absorption by the glowing iron or steel articles to be carbonized.

The apparatus necessary for the case-hardening process is fully shown in the illustrations, including a view of the front of several cylinders and a view of the rear of a single cylinder, together with the generator for the carbonizing gas. The upright cylinder standing on the floor is the gas generator, the pipe conducting the gas to the carbonizing horizontal cylinder.

The articles to be case-hardened are placed in the inner cylinder and the heat is applied through gas burners to the annular space between the inner and outer cylinders. The worm and worm-wheel gearing are provided to cause the rotation of the cylinder, this giving all parts of the work equal exposure to the carbonizing gas. The retort itself is supported upon two wheels at each end, this providing an anti-friction bearing, and also allowing for the expansion due to the heat.

The interior of the apparatus will be understood from the diagram. At *A A* is the retort itself, enclosed in the furnace with its lining of firebrick. Two of the supporting wheels are shown at *B, B,* and the lid is at *H.* The carbonizing gas is admitted through *L* and discharged through *J.* The heat is applied only at the central portion, and not at the ends. This central portion is defined by the




SECTIONAL VIEW OF CARBONIZING MACHINE

disc *I* and the opposite disc, and it is here that the work is placed. The disc *I* is connected with the lid by the tube *J*, the asbestos backing of the two discs being also shown. The retort is sealed at the lid, this bringing the sealing at a distance from the highly heated portion at the centre of the retort.

When the retort is to be discharged the lid and the discs connected with it are removed, and by operating a hand-wheel the rear of the furnace and the retort may be raised upon the hinge at the forward end and the contents discharged by gravity.

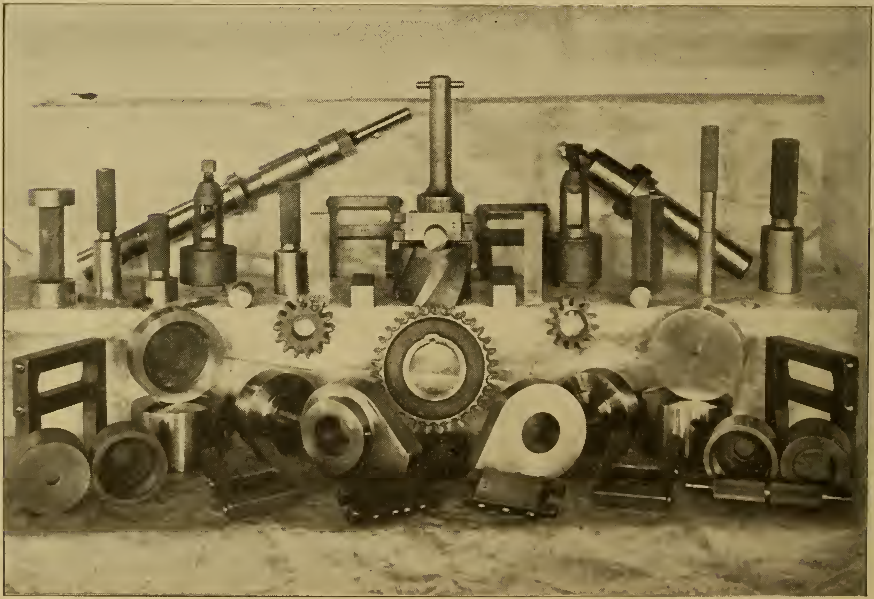
Special methods are used for different classes of work, in order to control them properly during the rotation of the retort. Thus, if the pieces are rings, they are strung upon bars secured in the retort in a longitudinal position. Likewise, if the pieces are round bars, which it is desirable shall not mar each other by coming into contact, they may be supported in the perforations of two or more thin discs arranged transversely in the retort, corresponding perforations, of course, being in line. These are made slightly larger than the bars, to permit a rolling movement when the retort is rotated.

A further difficulty arising under the old method and which is eliminated in the new is the tendency of the gaseous supply of carbon to rise. This would tend to increase the carbonization effected above at the expense of that effected below. By rotating the retort and circulating the gas this is obviated.

The accessibility of the work is something of marked importance. The work can be seen and its temperature judged directly and simply.

The hardening operation is effected by a special apparatus designed for the purpose. It consists of the tank which contains the quenching liquid. A kind of funnel is at one end. Here the hot pieces are received. They then fall into a rotating vessel, also in the shape of a funnel. This is perforated and lies in the liquid, its larger end being next the receiving funnel. The hardening articles pass to this lower and smaller end. Here they are raised and discharged by an apparatus, which is principally a conveyor arranged like a chain in a chain-pump.

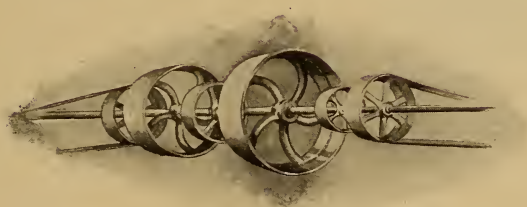
CASE-HARDENED PRODUCTS BROKEN TO SHOW DEPTH OF CARBONIZING. NOTE THE EFFECT AROUND THE INSIDE OF BOLT HOLES



FINISHED MACHINE PARTS CASE-HARDENED BY HYDROCARBON GAS

It would seem that the economy of the new process promises a very wide application of case-hardening. Thus, screws, nails, nuts, etc., may be cheaply treated, producing articles whose value would be enhanced by surface-hardening. As a method has been developed for straightening shafts while they are being hardened in the cooling bath, it seems possible that we may soon be able to purchase case-hardened and ground shafting by the foot and at commercial prices. This would mean a great deal in machine construction. The American Metal Treatment Company, of Elizabeth, N. J., which is engaged in case-hardening for the trade by the new process, is already treating a couple of short lengths. Thus, a shaft about a foot long and $\frac{7}{8}$ inch in diameter was hardened and straightened, with the result of being within 0.005 inch of absolutely straight. Another rod, with various diameters from $\frac{5}{8}$ inch to 1 inch and 22 inches long, was hardened and straightened within an error of 0.006 inch.

A further possibility of the process is that of the manufacture of high-carbon steel, the applicability of the method to this work being largely a matter of cost.



# THE FINANCIAL OUTLOOK FOR ELECTRIC TRAMWAYS

AS VIEWED FROM A MUNICIPAL STANDPOINT

By William R. Bowker

ELECTRIC tramways have come to stay, and of the several methods of distributing power to the cars the most practical and commercial system at the present time is the "overhead" supply, and, unless some surprising (and unlikely) developments occur, it will, to my mind, stay for many years.

As a convenience for a traveling public—opportunities presented for a localized low-fare tariff, the connecting and linking up of towns and cities, the opening out of suburban country, the increasing of land values in their immediate neighbourhood, and the facilities they offer for residence outside of the town centres (decentralization)—they prove invaluable, both from a point of view of public health and of convenient, cheap transit. So much for the undoubted (and, I hope, recognized) benefits to the community at large.

As regards the commercial aspect, the future outlook is none too promising, especially where municipal undertakings are concerned.

The initial cost of construction and equipment is so comparatively high, the capital expenditure in various directions being so great, and interest on invested capital, sinking fund, depreciation, reserve, renewal and maintenance expenses absorbing such a large percentage of the total receipts, in combination with the fact that the fare tariff is cut down so fine—these, in many cases, cause the surplus of net profit to be so small (and in other instances a negative quantity) that the ultimate financial outlook demands serious consideration.

The writer is not aware of one single large electric tramway that is making a handsome net profit of, say, 15 per cent.; and there are few indeed even showing a substantial net profit, say, of 5 or 6 per cent. on capital outlay. This is none too encouraging when it is realized that they are fully equipped with everything new and in good condition, and in nearly every instance had an already substantial passenger traffic (good-will, if you like) established.

The worst feature is the knowledge that many tramway undertakings, on their reserve and renewals funds basis, have not been setting aside or

allowing a sufficient legitimate sum of money under these headings fully to meet future financial obligations due to the fact that miscalculations have been made as to the probable life of certain branches of the undertaking, experience proving the estimates to have been too long. Not only that, but money has been handed over to relieve the town rates taken out of the surplus profits (i. e., the difference between total receipts and operating expenses only) without any provision having first been made to redeem borrowed capital, by sinking fund, reserve, renewal funds, etc. This is shockingly bad finance, and, to say the least, does not augur well for the future commercial stability of the undertaking.

Another consideration that must not be overlooked is that maintenance expenses will increase with time instead of decreasing. This is due to the fact that while the different sections of the system are new the first three or four years' maintenance expenses will not be so proportionately high as after an elapse of, say, eight or ten years' operation, wear and tear, etc., when more rapid deterioration sets in.

In the writer's opinion, it is questionable if many of the tramway undertakings which are ostensibly showing some small surplus profit on their capital outlay are in reality making any net profit at all, or even paying their way (i. e., if all financial obligations had been provided for). If the true state of affairs were thoroughly investigated, it would be found that serious miscalculations have been made as regards the probable life of certain branches or subjects of the undertaking, such that the amount (if any) laid aside to accumulate for a reserve and renewal fund has been entirely inadequate—in some cases being probably as much as 50 per cent. too low.

This is a grave problem that, sooner or later, will have to be faced, and the sooner the better, before serious financial difficulties tending to jeopardize the stability of the undertaking are encountered. Under some sections the probable life estimate will have to be cut down anywhere from 25 to 50 per cent. and the annual allowance put to one side (to create a substantial fund) increased *pro rata*.

Some very deep studying will be necessary to solve the fundamental economic problem as how, on the one hand, to increase the total receipts or income, and, on the other hand, to minimize the total expenditure and allowance.

Taking the case of large city tramway undertakings, this will have to be considered from two chief standpoints, viz., how to increase the passenger traffic with accruing receipts and decrease the operating expenses. (Note.—Operating expenses include traffic expenditure, general expenses, power cost and maintenance or general repairs.) A very close study of the proposition, going thoroughly into various details of organization and expenditures, will undoubtedly lead to suggestions and adoptions, with resulting improvement financially.

Commencing at the initial stage, assuming a tramway undertaking is in progress of installation, firstly, there is nothing ultimately to be gained, either practically or financially, by constructing a cheap, flimsy system, with the object of saving initial expense, for the money so saved will very soon be eaten up by increased renewal and maintenance expenditure, which latter could, in many cases, have been foreseen and prevented.

Heavy-weight rails with welded joints installed on a suitable and substantial foundation will repay themselves; likewise overhead equipment of ample strength and current-carrying capacity throughout will prove beneficial, and so on throughout the system in general. It is, of course, obvious that this will entail, say, an extra 10 to 15 per cent. initial expenditure of capital, to make it a satisfactory job; but that is of little consequence if, by so doing, the

life of the equipment is increased, say, 50 per cent., and the rate of depreciation, reserve funds and maintenance expenses are cut down 50 per cent. The difference between good and bad finance is substantial or flimsy construction, or an initial saving followed by a three-fold increase in yearly maintenance and other expenses.

Of course, it is recognized that increased initial expense (capital cost) means an increased annual allowance (sinking fund plus interest) on the capital invested; but this is not to be compared with the annual financial drain absorbed by a reserve or renewal fund and maintenance, especially the abnormal increase involved by a non-practical or non-durable equipment. Where is the financial gain or economy if, by saving 10 per cent. initial expense, the bulk of the system has to be practically renewed in, say, eight or ten years, whereas otherwise it would probably have had an increased useful life of from 50 to 100 per cent.?

When heavy initial expenditure is involved, great care should be taken that it goes in the right direction, where a practical and financial benefit results therefrom, such, for instance, as in engineering construction, suitable materials, with strength and weight wherever necessary; and, by all means, avoid wasteful expenditure on practically useless superfluities. In many cases accessories (especially where considerable quantities are used) absorb large sums of money; take, for instance, track drain-boxes on permanent-way construction. In the case of a level track they are of no practical advantage, being too much localized in action, and even when located on a gradient track it is questionable if sufficient practical advantages accrue from their installation to justify the expense outlay.

In overhead equipment superfluous ornamentation is costly, and in many cases could be done away with. Installing the right material in the right place (especially where durability and long life are essential) reaps its own reward.

Assuming the undertaking is all that can be desired, and that all foreseen advantages in construction and equipment have been adopted, the next thing is a broad-minded, up-to-date and sound commercial management to lead to a financially successful issue. It is imperative that the right man must be in command, as also the assistants and subordinates generally throughout the whole staff of employees.

The chief source of income will be gained from passenger traffic, and it is obvious that a financially stable fare tariff must be instituted, in combination with the most efficient disposal of the rolling-stock, so as to deal with any traffic that may arise.

The outlet of annual expenditure will be operating expenses and allowance for interest on unredeemed capital, sinking fund, depreciation, renewal and reserve funds.

If the undertaking has been installed in the best possible manner, the annual allowance to be set aside for a reserve and renewal fund can be pretty well gauged; and this plus the interest on capital expenditure and sinking fund can be provided for, and for many years this will not financially alter, i. e., increase or decrease, but remain at a practically constant annual contribution from the total receipts or income.

This will not be affected by any circumstances that can be done by studying traffic conditions, except in so far that the receipts should be sufficient to make due provision for them.

The chief problem is how to increase the receipts and keep them at a maximum and to keep operating expenses at a minimum.

Dealing first with the receipts, assuming a suitable fare tariff, the object in view should be to increase the passenger traffic, or receipts per car-mile. This can be attained by offering inducements to the public to

travel frequently over the system by opening up outlying districts and suitable resorts or parks where health-giving conditions and attractive amusements take place. An extensive and lucrative traffic can be gained in this manner, and also by offering such inducements in regard to fares as to attract people to live in the suburbs.

This is, of course, in addition to the fact that the greatest possible care should be taken to cater for the regular passengers, who travel to town and back on daily business.

Opportunities should also be taken to establish a car service between town and any large works that are erected in such convenient places that the cars would be patronized by a large number of work-people. The car and time service will need careful study in every detail, so as to profitably carry all the passengers attainable, and car routes in particular will require well looking-after, especially in somewhat isolated districts or certain directions, to see that the car and time service are not either too large or too frequent to cater for the traffic demand; otherwise a two-fold loss will be entailed in (a) utilizing too many cars, with their attendant labour expenses, and (b) a useless power expenditure—such that good profits made on certain car routes are partially or wholly nullified by losses sustained on other car routes.

The ideal condition is to attain an all-round maximum efficiency. Sufficient rolling-stock should always be available to cope not only with the regular passenger traffic, but also with any abnormal and profitable rush of traffic that may be liable to occur.

The fare tariff should be so based that the receipts accruing therefrom would be sufficient to pay all expenditures and leave a surplus net profit, and at the same time be so attractive and low in figure that it would induce passengers to travel frequently to and from home to business, and also to travel by the tramcars in preference to other means of locomotion.

Advantage should also be taken (wherever the opportunity presents itself) to act as feeders either to the railways or motor-bus traffic, and by arranging mutually beneficial through-running powers on adjacent tramways; for railroads are here to stay, as also are motor buses, and there is not the least doubt but that there is a mutually lucrative field to be catered for by acting on the principle of "feeding" one another.

Full advantage should also be taken of opportunities for increased traffic, such as race meetings, football and cricket matches, and attractions of various kinds, etc.

Side issues, such as the letting out by contract of advertisements on the cars, should not be ignored, for from several hundreds to several thousands of pounds (according to the size of the undertaking) can annually be obtained from this source, and the letting of this privilege is a valuable asset to a tramways system; in fact, the acceptance or rejection of such a golden opportunity may mean the difference between the net financial gain or loss on the year's working.

The side issue of the carriage of parcels on an extensive city undertaking with a frequent and dense passenger traffic is impracticable on a large scale on the passenger cars, and if carried on by horses, vans, lorries or motor vehicles its adoption involves too many liabilities and complications, with too little hopes of ultimate substantial profit, for the writer to be at all favourably impressed by its possibilities.

The carriage of merchandise at night-time from town to town over adjacent tramways is far off as yet, inasmuch as a big and profitable business is concerned, and not much increase in receipts with profits from this source can be immediately looked for or anticipated at present.

Turning our attention to the annual expenditure with a view to minimizing it, the first essential is

that every man employed (from the highest official to the lowest) should be a source of profit to the undertaking, i. e., the full value should be obtained for the wages or salary paid for his services, and certain economies in this direction can usually be effected by making a systematic study of the several different departments and dispensing with superfluous labour.

Economies can be effected in power consumption (a serious item of expenditure) by offering a system of bonuses for motormen who effect saving in this direction and also for freedom from accidents, and to conductors for civility, good conduct, general cleanliness and freedom from complaints, and also to both motormen and conductors who keep their uniforms in good condition and prolong their use for from, say, six to twelve months above the stipulated time.

One or two hundred pounds expended in this direction will come back with good interest to the tramways, and, in addition, will tend to make the men more ambitious, efficient, and take a greater interest in their duties, all of which are to the financial benefit of the undertaking in general. Then, again, it tends to cement or consolidate good-will and harmonious working (an ideal condition not to be lightly cast aside); and dissatisfaction and real or imaginary grievances are not so frequent amongst employees so treated.

Economies under a maintenance heading can be effected by a thorough systematical and periodical inspection of the permanent way, overhead equipment, rolling-stock, buildings, plant and equipment in general, and immediately making good slight defects or repairs, and not to wait until complete renewal becomes necessary. Efficient maintenance will effect a great saving in renewals.

If very weak spots are discovered in engineering or other important places where durability and long life are essential, it is not a wise policy, financially, to patch up, but to renew the defective part in a substantial manner, and in all cases of renewal (especially where excessive wear or rapid deterioration takes place or certain faults develop) it is advisable to take full advantage of any information which may be to hand, gained by experience on one's own or other tramways throughout the country, as regards the durability, suitability and practicability of certain materials or details of construction.

The fact must not be lost sight of that sound judgment, forethought, wise discretion and prudent action are highly essential in all and every movement.

The whole secret of success lies in outlining a broad-minded, up-to-date policy, a combination of practicability with commercial stability. Thorough organization is essential in every detail, including a careful study and the gathering of valuable information and statistics from various sources, together with systematic and periodical inspections and the immediate repair of minor defects, before they become magnified into serious faults (which necessitate complete renewal). Bonus systems should be adopted wherever applicable and mutually advantageous, the employees being treated in as generous a manner as possible without jeopardizing the financial stability of the undertaking.

As a final word, strict check should be kept upon the stores, with a view to minimizing as much as possible the continual drain on the same. In many cases several hundreds of pounds may be annually saved in this department.

If economies are to be introduced, it is just as important to economize in small things (especially where considerable quantities are used) as in big details.

# TRAFFIC CONGESTION IN NEW YORK

By George Ethelbert Walsh

IN the praiseworthy effort to solve the rapid transit problem of New York City nearly all of the civic bodies have strenuously advocated the building of subways and bridges, and the costly systems of tunnels and bridges now in operation or soon to be opened to the public are handsome testimonials to the achievements of this generation. But while light is gradually being let in on the rapid transit problem, the freight congestion of the city is apparently worse off than ever, and, with the growth of the city, it must continue to loom up larger and become more difficult to handle. Chicago reversed the order of New York, and instead of building underground rapid transit systems for passengers, it constructed tunnels underneath the city for freight traffic. In putting its heavy freight traffic underground, Chicago relieved its streets of trucking congestion some 50 per cent., and the tunnels are not yet nearly taxed to their full capacity.

Many downtown streets of New York have a heavier freight traffic than any similar thoroughfares in the world, and the freight congestion of the streets have such an important bearing on the surface passenger service of the city that the cars, in many instances, cannot keep to any decent schedule. The traffic squad of policemen have done excellent work in regulating the trucking of the business and shopping districts, but with the growth of the city the difficulty of handling the question will steadily increase.

New York has both the advantages and disadvantages of a great seaport town, and its commercial supremacy has never been seriously questioned. Railroads centre there and pour their freight into the city from the north, east, west and south, and the great steamship lines bring cargoes from all parts of the world to the metropolis for distribution. In 1906, out of $776,000,000 worth of merchandise imported only $40,000,000 passed through without paying toll. The annual hauling bill of the city costs $35,000,000, and the lighterage service, at 3 cents a hundred pounds, costs another $50,000,000. The total foreign commerce of the port is increasing at the rate of 10 per cent. a year, or 50 per cent. in half a decade. A few years ago the largest number of cars containing freight packages sent into the city by a single railroad was 500, but to-day it is not uncommon for the Pennsylvania or the New York Central Railroad to squeeze more than a thousand into the city in a single day.

The cost of handling freight in

New York is on the increase simply as a result of congestion. During an active month a cost of 10 per cent. is added to the transportation of freight because of the time and labour expended in pulling down piles of freight to find the shipment demanded by one firm. The congestion is so great on the railroads and steamship piers that freight at times is held several days simply through the physical impossibility of reaching it. The agent of one of the big New England navigating companies admits that the handling of freight on his piers has increased from 28 to 38 cents a ton as a result of the congestion of affairs. A visit at an early morning hour to any of the piers where the railroads or steamship companies dump their enormous freight in a steady stream, will show long lines of trucks waiting for a turn to get their freight. It costs $7 a day to maintain a two-horse truck, and literally hundreds and thousands of these are kept waiting in line from two to six hours. It is due to this wasted time that New York pays a trucking bill sufficiently large to pay the running expenses of a good-sized city.

But the congestion at the piers and railroad terminals is not the whole story. The streets are congested and so crowded that movement of freight is slow and clumsy. A single breakdown of a truck may interrupt traffic for hours. Upward of a dozen trucks are delayed several hours in the crowded districts through the overloading of a truck in bad winter weather or by the breaking of an axle. This happens not only in one part of the city, but in a score. One snowstorm may thus cost the city thousands of dollars a day in trucking bills.

The Island of Manhattan is too full; no one attempts to deny that; not only too full of people—which is almost a self-evident truth—but too full of freight traffic. Its streets are arteries through which the life-blood of the nation often stagnates instead of flowing steadily in a limpid stream. From terminal to terminal, and from pier to pier, the great freight stream pours, crossing and recrossing, and often making wide detours to reach its destination. The cry of railroads and steamship lines is for "room, and more room"!

The problem is a difficult one to solve, and one that has engaged the serious attention of a dozen civic bodies and many experts. The conditions of to-day demand a rearrangement of traffic for the future, when the city has doubled in population and becomes more dominant in the country's commerce than ever. The fear that New York may, in time, lose some of its commercial supremacy through high port charges and excessive cost of transportation of goods has sufficient foundation in fact to make the problem of improving conditions a vital one. An agent of a steamship company is authority for the statement that "New York has lost the handling of $25,000,000 worth of dry goods within the last year through the delays due to shipping through the city, the goods having been forwarded by other routes."

New York has a good water frontage of about 130 miles, but if all the waterfront possibilities were properly developed and utilized there would be some 450 miles that could be brought into practical use. In the past the freight congestion has been chiefly in the downtown districts, and the effort has been made to utilize too small a waterfront for an expanding commerce. There are practically only about a dozen to fifteen miles of waterfront on Manhattan Island now available for ocean freight traffic, but the whole circle of the island could be improved so that piers could be constructed for relieving the present docking congestion. Liverpool has invested some $200,000,000 in the improvement of its docks; but New York, whose deep-sea traffic is of greater importance, has done little to develop a comprehensive dock system. All told, the city has some

767 piers, of which 309 are in Manhattan, 197 in Brooklyn, 138 in Staten Island, and the rest in Queens and the Bronx.

The problem of relieving the freight congestion in New York resolves itself around the establishment of new railroad terminals and the development of the docks and piers, so that the whole of the waterfront can be utilized instead of only a comparatively small area of it. As far back in 1898, when a commerce commission was appointed by the Governor to look into the dock problem of the city, the question of relieving the freight traffic was considered a pressing one, and in the report of the commission the following was written: "That New York is indifferent, is a matter of comment in other seaports, where achievement follows upon achievement, while New York sleeps."

But the change that has come over the city in grappling with its rapid transit problems is evidenced to-day in the effort of its different civic bodies to solve the freight distribution question. A freight-tunnel system for the collection and distribution of local freight is apparently out of the field, in view of the demand for subways for passenger service. A second proposition, to establish a series of elevated tracks for freight transportation, seems likewise impracticable. Both of these systems have been considered by committees appointed by the Chamber of Commerce and other civic organizations, and, in view of the need for more subway passenger routes and the general opposition to more elevated tracks for any kind of transportation, it is not likely that results could be obtained from the advocacy of either for many decades to come.

The proposition to establish a series of railroad terminal centres utilized by all the trunk lines, and the development of a comprehensive docking system closely articulated with the railroad terminals, has received the greatest amount of study and approval of all the plans suggested. Such railroad terminals could not be located on Manhattan Island, and they would have to be in a region where there is plenty of elbow-room. This would mean that they would have to be in New Jersey, the Bronx or over in Brooklyn. The terminal yards would provide for such ample room that congestion would not follow for years to come. The condition of trade has already determined, to a certain extent, the location of terminals for the storage of goods of different classes. Grain is apparently stored to the best advantage on the New Jersey shore, cotton on Staten Island, coffee and a good deal of low-grade freight in South Brooklyn. By this system of storage terminals irregularly worked out by the trade, a good deal of the heavy freight which was formerly shipped direct to Manhattan and often twice carted across the island is now never trucked into the city until actually needed for consumption. By landing only such freight as needed for immediate use on Manhattan Island, the freight problem receives a partial solution.

But the need of better storage and distribution centres for the future is imperative. The big Bush terminal in South Brooklyn has already formed a nucleus for the proper development of the freight traffic in one section. There is a classification of freight at these terminal storage houses, so that long lines of cars or trucks do not have to wait for hours to get a chance, and there is no pulling down and piling up of freight to get at the goods of one firm.

The possibility of Jamaica Bay as a great terminal centre for freight has been variously discussed, and the practicability of maintaining a channel from the ocean into the bay was regularly passed upon by United States Army engineers a year ago. The tracks of the Pennsylvania's connecting railroad pass so close to the bay that direct access may be had to New England and the West. The

opportunities for building extensive piers and docks for ocean steamers here are great, and the importer and exporter would thus meet on a common ground in a terminal reached directly by a railroad trunk line and ocean steamers. The development of Jamaica Bay into a great basin for the docking of ocean steamers, where deep-sea freight could be transferred directly to cars, would undoubtedly eliminate many of the evils which congest the city and river fronts of to-day. Another possible terminal centre is in Flushing Bay or East Chester Bay, in the Bronx. The tracks of the New York Central and the New York & New Haven Railroads would thus meet the ships coming up the Sound, forming a great transshipment point for heavy freight. Both of these terminal centres offer available room for the development of comprehensive systems of freight distribution, but within a few decades the population will enhance the value of land to such a point that the enterprise will become increasingly expensive and difficult.

The conclusions of nearly all the expert commissions and engineers are that the trucking bill of New York could be cut nearly in half if its freight were more economically distributed in bulk upon its first arrival. This can best be accomplished by establishing classified docks and distributing points where the goods can be delivered without unnecessary carting across the city, or lightered down the rivers from one point to another. This would tend, in time, to a rearrangement of shipments by routes best enabling certain lines of goods to be handled and laid down at the storage houses.

The situation for the wholesale merchandise houses has not been satisfactory in New York for decades, and the complaint in busy seasons that goods cannot be shipped quickly and economically is an important one. Every year during the rush season dry goods merchants declare that their business is limited by the shipping facilities of the city and not by the demand of outside customers. St. Louis made the experiment over ten years ago of establishing a great freight terminal centre where the wholesaler, jobber and manufacturer could meet. The Cupples station consists of a series of large brick buildings of the regulation warehouse type, covering 30 acres of land. Spurs and switches extend from the tracks of the Terminal Railway into each of these buildings, and freight intended for any of the thirty wholesale firms is unloaded from the cars to the trucks by hydraulic lifts. The saving to the firms is reported to be from three to four million dollars annually.

The only example of this kind in New York is the Bush Terminal, in South Brooklyn, where there is a series of piers, 150 feet wide and a quarter of a mile long, with fireproof warehouses behind them. The cars are brought to this terminal by lighters and the freight delivered directly to the ocean steamers, or ocean freight is delivered to the cars and then lightered to its destination. Only goods intended for local trade are carted away, and freight that must be stored can be kept in the warehouses until needed. This system has proved as satisfactory and profitable as the Cupples station in St. Louis. But one such terminal centre is a small factor in the New York situation, and it needs duplicating many times in other sections to relieve the present congestion.

The importance of making the Bronx a great eastern terminal for the city's freight traffic is admitted by all, but this necessitates the widening and deepening of the channel through the East River to the Sound. The agitation to remove all obstructions to such navigation to the Eastern States is now voiced by residents of the Bronx and by the navigation companies using that route. The preliminary work begun at Hell Gate should be carried on by the Government until the waterway from the

East River to the Sound can accommodate the largest of the steamers without risk.

The solution of freight congestion in the city is thus one that can best be answered by cutting down the amount of traffic carted across the island. It is a study in economical distribution, not by reducing the amount of goods, but by sending them along the shortest and nearest routes. Millions of dollars' worth of merchandise are frequently carted two and three times through the city when one should suffice. But to do this, and to shorten the trucking routes, there must be a comprehensive system of docks in all parts of the city so the freight can be distributed easily. Immense relief can be obtained by better pier facilities. The steamship companies and railroad lines must have better terminal facilities and the wholesale houses better systems of warehouses located at convenient shipping points. It is a problem that must be worked out within the next decade or New York's freight congestion will equal, if not exceed, that of its population.

# GAS ENGINE DEVELOPMENT PROBLEMS

By Henry Harrison Suplee

THE gas engine has been before the engineering world in an operative form for more than a quarter of a century, and in an experimental and theoretical shape it has been known nearly as long as the commercial types of the steam engine. Its progress during the later years of its existence has been greatly aided by the development of the producer, by the utilization of furnace gases, and by the practical knowledge and experience which have enabled the large gas engine to become an accomplished fact, and there are indications on every side that in the immediate future the internal-combustion motor will take its place as the active rival of the steam engine, either of the reciprocating type or as the steam turbine, in the power plants of the world.

At the same time there have been certain obstacles to the rapid development of the gas engine as a prime mover for commercial plants which have retarded its progress; and, as in most such cases, these obstacles continue to exert their influence after they have really ceased to exist. Nearly every power-plant engineer, when asked what he thinks about the gas engine, replies in terms of approval of the machine as an efficient device for the conversion of heat into work. He admits the high economy which has been attained; he accepts the theoretical advantages which have been demonstrated; and, in general, he is favourably inclined. When, however, he is urged to instal gas engines and producers, instead of steam engines and boilers, in some important power plant which he has in hand, he will almost invariably hesitate, and proceed to explain that while the superior economy of the gas-power plant would be very desirable, he prefers to wait until the question of the reliability of the machine, under continuous practical service, has been demonstrated.

An eminent engineer, not long ago, remarked, that in power-plant service there were three things demanded of an engine: "reliability! Reliability!! RELIABILITY!!!" Few will dispute this dictum, but it is time that the fallacy that it cannot be met by the internal-combustion engine should be disproved. The facts show, to-day, that the modern gas engine is as reliable a machine as the steam engine; that the gas engine and its accompanying producer form as reliable a set as the steam-generating set, either of the reciprocating or the turbine type; and that the bogey of unreliability of the gas-power plant is a thing of the past, to be relegated to the limbo of the historical museum.

In order that these statements may be verified, some facts are subjoined which, it is believed, will take the matter of the relative reliability of steam and gas engines out of the sphere of dogmatic opinion, and place it upon a basis of fact.

The earliest extensive practical attempt to utilize the discovery of Thwaite as to the availability of waste furnace gases in the gas engine was made by the Cockerill Works, at Seraing, near Liége, in Belgium. This engine was set to work in 1900, not at any unimportant or intermittent task, but in one of the most exacting departments of iron-works service, the supply of blast to the furnaces. Since that time the entire power-plant department of the Cockerill Works has

been transformed, and to-day there are no steam engines used in the Works at all, the blast and the motive power alike being derived wholly from internal-combustion engines, supplied with fuel directly from the blast furnaces and coke ovens of the Works. Any one who realizes the absolute necessity for the continuous and reliable operation of the blowing engines of a large iron-works will understand that this record furnishes one of the most positive and practical reliability tests on record. Similar records exist in Germany, as, for example, the Krupp Works at Rheinhausen, employing 26 gas-power blowing engines, totalling 36,000 horse-power.

Speaking upon the same subject, Mr. E. T. Adams, in the November issue of this magazine for last year, referred to the fact that before placing an order for nearly 200,000 horse-power of gas engines for blast furnace service, the officers of the United States Steel Corporation made an experimental installation of two gas-driven blowing engines of 3,000 horse-power each for the Edgar Thompson Works at Pittsburg, but that the results already attained in Europe rendered it unnecessary for them to await the experience with these engines, although the Edgar Thompson engines are entirely successful in their trying service. When, as Mr. Adams stated, there are in service or on order for use in the steel industry of the United States gas engines aggregating 350,000 horse-power, it is surely time to cease wondering if the gas engine is as reliable as the steam engine.

Not only with large engines, producing blast for iron furnaces, but also with smaller machines has the reputation for reliability equal or superior to that of the steam engine been established. Thus Messrs. Crossley Bros., the firm which practically introduced the original Otto "silent" engine to the British trade, now offer to supply gas engines for regular continuous service, this meaning operation in actual service for 24 hours a day, for 6 days a week; the run beginning on Monday morning and continuing until Saturday night. This is not offered as a test, but for regular service.

As confirmation of the capability of such engines for this kind of service the fact may be cited that a Crossley engine of 120 horse-power was operated at the works of Messrs. Bruner, Mond & Co., Northwich, continuously without stop for seven months, in electric generating service.

It is generally assumed that marine service gives a severe trial of the reliability of the engine used for motive power, and one of the great triumphs of the steam engine is its reliability in the maintenance of uniform propulsive power in navigation. The gas engine has not yet had opportunity of showing what it can do in large powers on shipboard, but so far as it has been tried it has given good account of itself. The Capitaine system, as built by Thornycroft, was given a series of exhaustive trials in the Solent in 1906, the results being eminently satisfactory, ten-hour runs being made repeatedly without failure or interruption, while a canal barge on the same system made a trip of 600 miles through the British canal system without the slightest difficulty on the score of reliability.

The numerous and convincing endurance runs which have been made with gasoline engines with which automobile vehicles have been fitted demonstrate the reliability of these little combustion motors. Formerly the automobile was the butt of the humorist, and sketches and jokes about the unreliability of such machines filled the papers, but this has now become a piece of ancient history, and the trials which have been made in all parts of the world demonstrate that the motor is by far the most reliable portion of the whole vehicle, delays and interrup-

tions in service arising far more frequently from tire troubles and from defects in the general construction than from unreliable action of the motor.

The same is true of combusion engines of this type in marine service. The gasoline launch has been found such a reliable machine that its use for all kinds of service is accepted as a matter of course, and no one hesitates to use these motors on the score of unreliability. Probably the most conclusive demonstration of the entire reliability of the gasoline motor for marine service is found in the trip of the Gregory, one of the torpedo boats built by Mr. Lewis Nixon for the Russian government, this little vessel having made the trip across the Atlantic, through the Mediterranean, and into the Black Sea to Sebastopol entirely under her own power.

The reliability of the combustion motor is a matter altogether independent of size or power. We have seen that the large, gas-driven, blowing engines for blast-furnace service have fully demonstated their reliability for the extremely trying work to which they are applied. Similar results have been obtained from small engines, using gas from either suction or pressure producers. To cite but a few examples, we may note that a 30 horse-power Westinghouse gas engine was installed at Poughkeepsie, New York, in 1905, in connection with a producer built by R. D. Wood & Co., for use with the low-lift service of the waterworks, raising water from the Hudson to the filter beds. This engine was operated regularly, 24 hours a day, six days a week for nearly three years, without interruption or failure. Although used only on the low-lift service, it handled all the water supplied to the city, so that a failure would have meant an interruption to the supply, and yet such was the confidence felt in the engine that no spare source of power was supplied, nor was any needed.

Another example is that of the plant at the works of the Phœnix Tube Company, Brooklyn, New York, where gas from a producer by R. D. Wood & Co. supplies a Westinghouse engine and a Nash gas engine, aggregating 150 horsepower, this plant having furnished the motive power for the establishment for five years without any evidence of unreliability.

A plant worthy of note in respect both of reliability and efficiency is that installed at the works of the John Thomson Press Company, Long Island City, New York. Here there are two engines, one of 125 horsepower and the other of 50 horsepower, both drawing gas from one suction producer, this latter being of the type designed by Mr. Tait, in which no steam is used, the gas consisting, so far as its combustible portion is concerned, almost entirely of carbon monoxide. This plant has been running regularly for 18 months, a portion of the service being 24 hours per day, and a portion 10 hours. It is interesting to note that the maximum fuel consumption in this installation is 1.25 pounds per horsepower hour, while with full load the engines have shown performance of 0.7 pound per horse-power hour.

One of the most severe kinds of work which a power plant is called upon to perform is that in connection with the manufacture of cement. The record of the Iola Portland Cement Company, Kansas, is therefore interesting to the gas-power engineer. This plant contains 4,500 horse-power of gas engines, including three horizontal engines of 500 horse-power each, and fourteen vertical engines, averaging more than 200 horse-power each. The records for the early part of last year, covering a period of four months, show that the average of the elapsed time during which the horizontal units were operated was 95.6 per cent.; while the 300 horse-power units ran 98.4 per cent. of the time, and the 140 horse-power units 97.5 per cent.

The total time lost by shut-down for repairs averaged only 0.63 per cent. for the horizontal engines, and 0.48 per cent. for the vertical engines. Taking the horizontal engines of this plant, as being of the later type, their operation represented 23.17 hours per day, for a period of four months, and this in the trying, dust-laden atmosphere of a cement works.

Cold storage plants make severe demands upon the motive power, owing to the fact that interruptions in the service must not be permitted to occur.

The gas engine has shown itself fully capable of meeting this service, however, and some examples will show. Thus, at the establishment of Hall & Carroll, Dover Plains, New York, a 20 horse-power Nash engine operates continuously from August to December, each year, without stop. Similar service is rendered by a 10 horse-power Nash engine, installed in 1898 at the cold storage plant of Rhodey & Smith, Tompkinsville, Staten Island, N. Y.

Another example of reliability is seen in the case of an 85 horse-power Nash engine in the plant of the Colburne Machine Tool Co., at Franklin, Pa., which made a continuous run of 24 hours a day for four consecutive months.

It would be entirely possible to continue enumerating examples of the above kind to demonstrate the fact that the combustion engine has shown itself as reliable as the steam engine under both regular and exceptional conditions of service, but it is apparent that the facts can be obtained from every line of work to which the internal-combustion engine has been applied and that the feeling of uncertainty among power-plant engineers about it is wholly unwarranted.

Apart from the question of operative reliability the comparative life of a steam and a gas-power plant is a matter concerning which differences of opinion will be found to exist, so that some definite data on these points may be presented. The question of the life of a power plant involves also the important matter of depreciation charges, and hence it becomes of primary importance in considering the type to be installed. Probably the most complete records available for this purpose are to be found in the experience of the Westinghouse Machine Company, and in a paper in the November issue of this magazine for last year, Mr. Bibbins gives some figures which are worth repeating in this connection.

Referring to the vertical, single-acting type of steam engine records of shipments, repairs and replacements, covering a period of nearly 20 years show that the average life of engines of this type is about 25 years. Similar records for gas engines of the same general design, covering about eleven years, show almost the same result, the life being very slightly less than with the steam engine. So far as repair bills are concerned, these figure out, on engines actually in service, about 1½ per cent. for the steam engines, and about 2 per cent. for the gas engines. In either case the engineer is warranted in assuming an average life of 20 years, giving a straight depreciation of 5 per cent., or on a sinking-fund basis, at 4.5 per cent. interest, a depreciation rate of 3.187 per cent.

Mr. Bibbins points out that the depreciation of the engine and the producer should be considered separately, the latter representing only about one-fourth of the total valuation of the plant, a plan which should also be followed with the boilers in a steam plant.

Broadly, then, we see that the internal-combustion engine, with its producer and equipment, is entirely capable of giving results fully as reliable as the steam engine, these facts being sustained by results in continuous practical service in iron works, water works, electric-generating stations, manufacturing establishments, cement works, marine

service, and vehicle propulsion. What has been done can be done again. To maintain, in the face of such records, that the gas engine is unreliable, is simply to admit that the objector himself feels that he cannot do what others have done and are doing, a position which few power-plant engineers would be willing to assume. The fact is, that such timidity as does exist is largely due to a feeling which is the outgrowth of the early experimental period, a period which was of the utmost value in creating the present reliable practice, but a period which is as fully outgrown as the similar era in the development of the steam engine. Every department of engineering work has passed through the stages of experiment, theory and slow development in the face of operative difficulties, to the full swing of broad commercial success. The history of engineering teaches the inspiring story of success attained by mechanical genius associated with indomitable courage and energy in the face of natural and artificial obstacles. With the progress of applied science, however, results which formerly were achieved only in the slow course of centuries, are accomplished in a few short years. The isolated inventor, laboriously developing his ideas with limited resources and often against opposition and discouragement, is replaced by the trained scientist and engineer, backed by the resources of great corporations, and provided with ample facilities of laboratory and workroom. The result is the thorough development, in a comparatively brief period, of ideas which formerly had to struggle with obstacles almost insurmountable. Such has been the development of the gas engine. A motor which, in the course of ten years, has risen in dimensions from a maximum of 200 horse-power to more than 4,000 horse-power is entitled to be regarded with the utmost respect in the field in which it has entered.

A motor which has transformed the entire system of highway travel, which is invading the high seas, which is meeting the demand for the conservation of the fuel supply of the world, which forms the principal object of interest to the power-plant engineer in all departments of work to-day, has fully attained its majority, and stands on its record and on its merits.

# MODERN HYDRAULIC MACHINERY

By Carl Wigtel

IN previous articles on modern hydraulic machinery some account has been given of pumps for generating hydraulic pressure and the arrangement of mains for its distribution. A number of illustrations have also been given of hydraulic jacks, small, portable hydraulic tools, and hydraulic presses, operated either by hand pumps or by small motors operating pumps attached to the various machines.

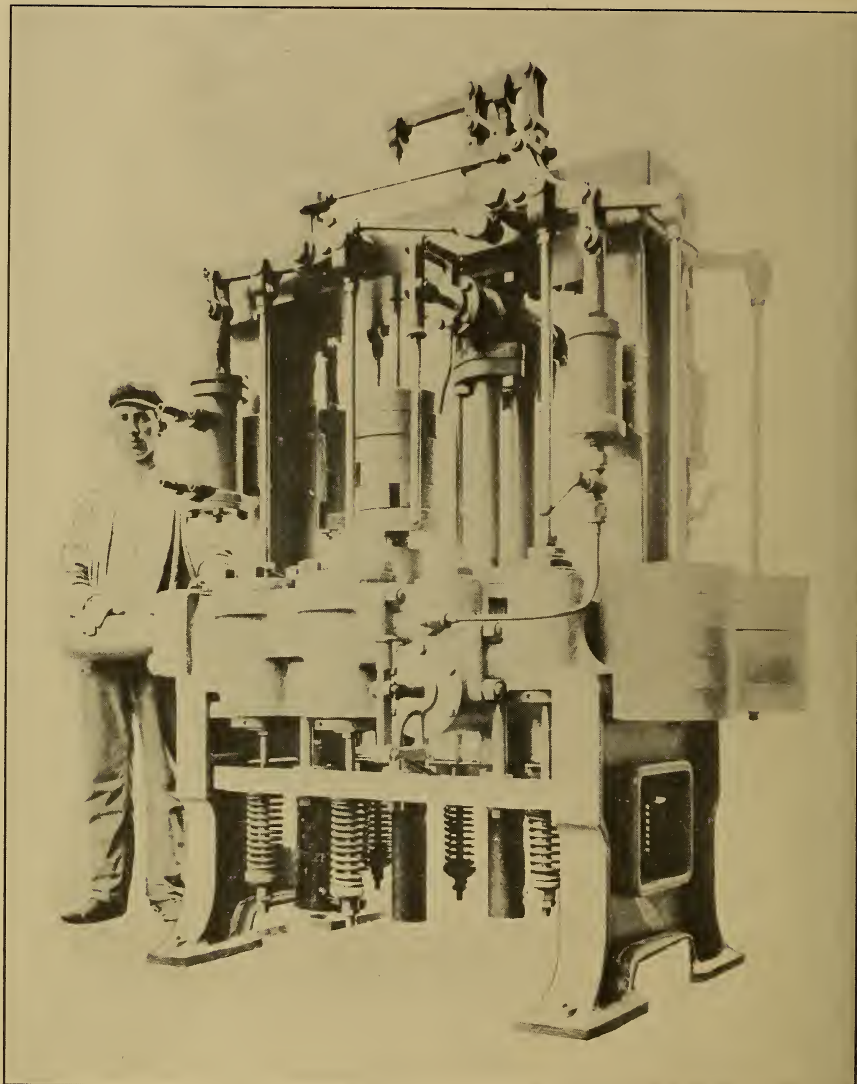
The regulation and control of such machines, owing to the slow action of the ram, is generally effected by poppet valves, or by screw stem or needle valves, acting upon the supply to the press plungers. Valves of these styles are generally slow in opening and closing, and for high pressures and large areas the limit is soon reached in direct valves of this kind, on account of the difficulty of opening and closing them against the high pressures involved. The natural remedy for this difficulty lies in the use of balanced valves, and several forms of such valves have been devised, some of these being fairly satisfactory, although the really perfect hydraulic valve is yet to be discovered. The operating valve is generally the weak link in every hydraulic installation, and the valves at present in use require continual attention in order that they may be kept in good order.

For low pressures ordinary slide valves are sometimes used, and if the fluid is not too gritty and the pressures are low, they give fairly good satisfaction. When low and medium pressures are employed, balanced piston valves are used, these being fitted with leather packings passing over open ports. With such valves, however, the packings need frequent renewals, owing to the wear and tear occasioned by the passage of the packing over the open ports.

One of the best types of valve for large valve areas and high pressures is that using two spindles, one for admission and one for discharge, the spindles being of the same diameter as the opening through the valve seats, and, therefore, being practically balanced. The pressure fluid is prevented from leaking out by the use of U leather packings around the spindles; and, owing to the fact that the moving spindles are smooth and the packings pass over no open ports, they last a long time. The valve seats need regrinding occasionally, but the repairs on valves of this kind may be kept at a minimum by keeping the fluid free from grit and impurities. The two spindles are opened and closed by a hand lever, operating a lifting-cam beneath.

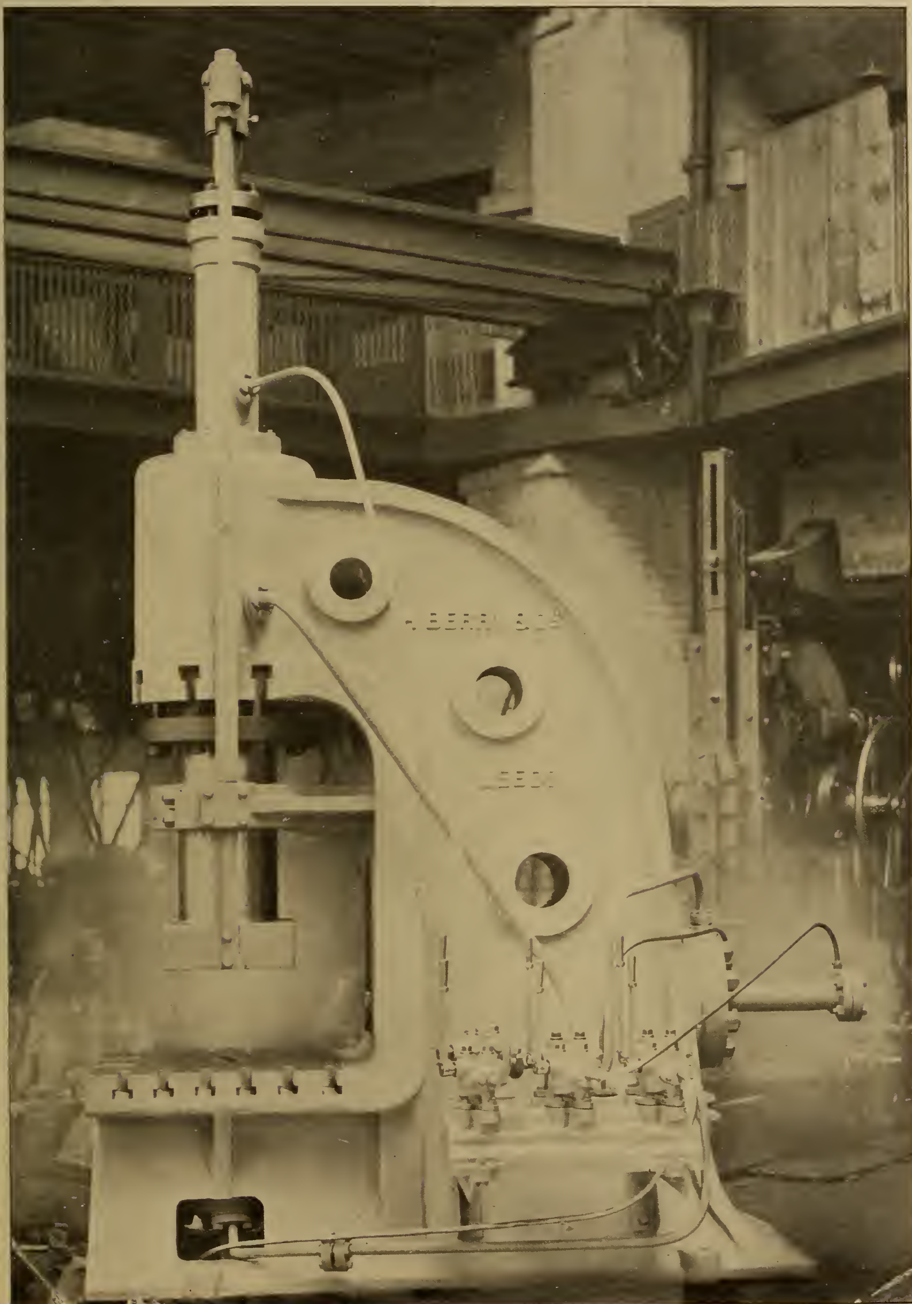
Special hydraulic machines containing a number of hydraulic cylinders require a number of such valves, and the various illustrations will show such applications. The parts are often arranged in such machines so that the operator does not need to give any especial attention as to which valve is to be opened next. Thus, an eight-spindle valve is so arranged that one revolution of the wheel opens and closes the eight valves in the order required for admitting and discharging the low-pressure fluid to three hydraulic cylinders, and also to a hydraulic intensifier, which, in turn, admits high pressure to two cylinders, the spindles being operated by cams on the shaft.

Among the illustrations is shown

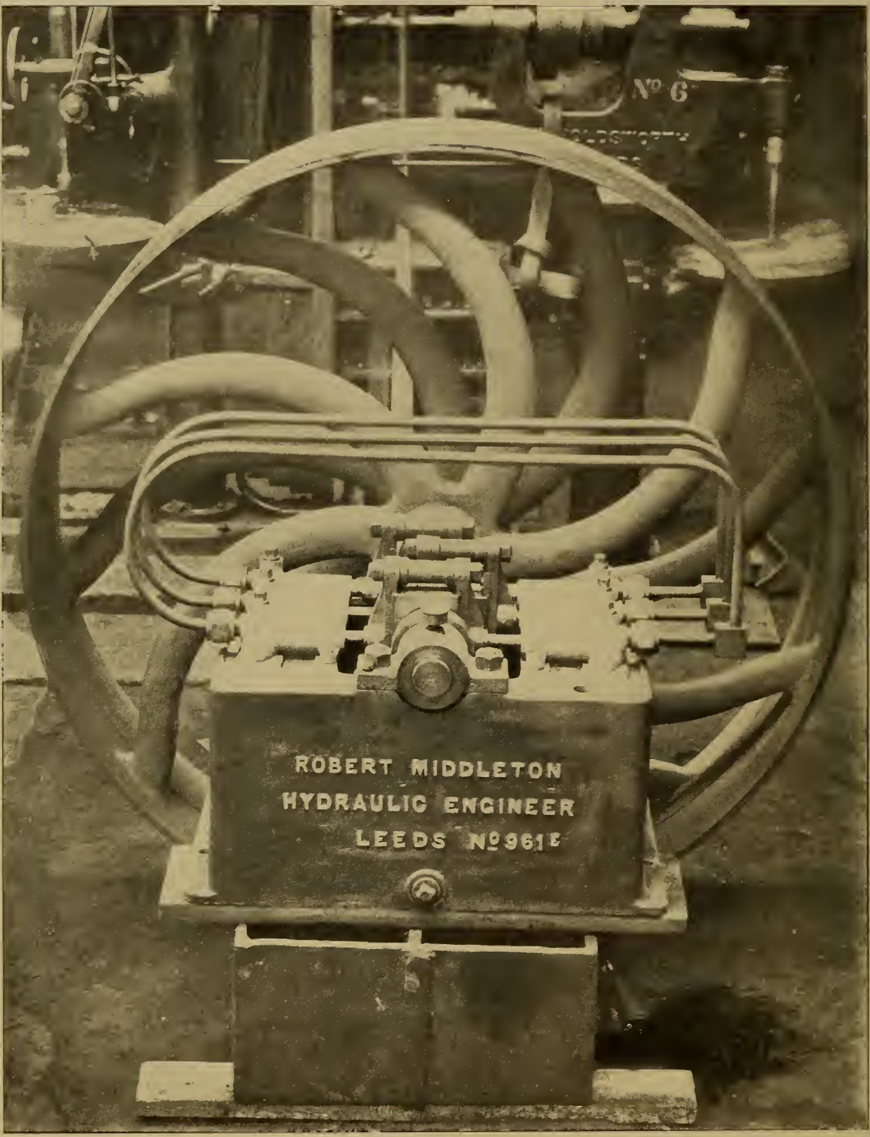


AUTOMATIC CONTROLLING VALVE FOR HIGH, LOW AND TWO INTENSIFIED PRESSURES
THE WATSON-STILLMAN CO., NEW YORK

a 5-inch, six-spindle valve with automatic controlling mechanism. This valve is started by two small pilot valves, which admit the pressure fluid to two small cylinders, which open the low-pressure admission valves for a pressure of 150 pounds per square inch. The second spindle is opened automatically, admitting a pressure of 1,000 pounds per square inch to the press cylinders, and when this pressure has exerted its force, a pressure of 2,000 or 3,000 pounds is admitted from an intensifier to the press cylinders. The valve is double, having two sets of three spindles, which, in rotation, admit the pressures above stated to two sets of large cylinders. Both sets of cylinders are discharged in unison when the pilot valves are reversed. The special machine operated and controlled by this

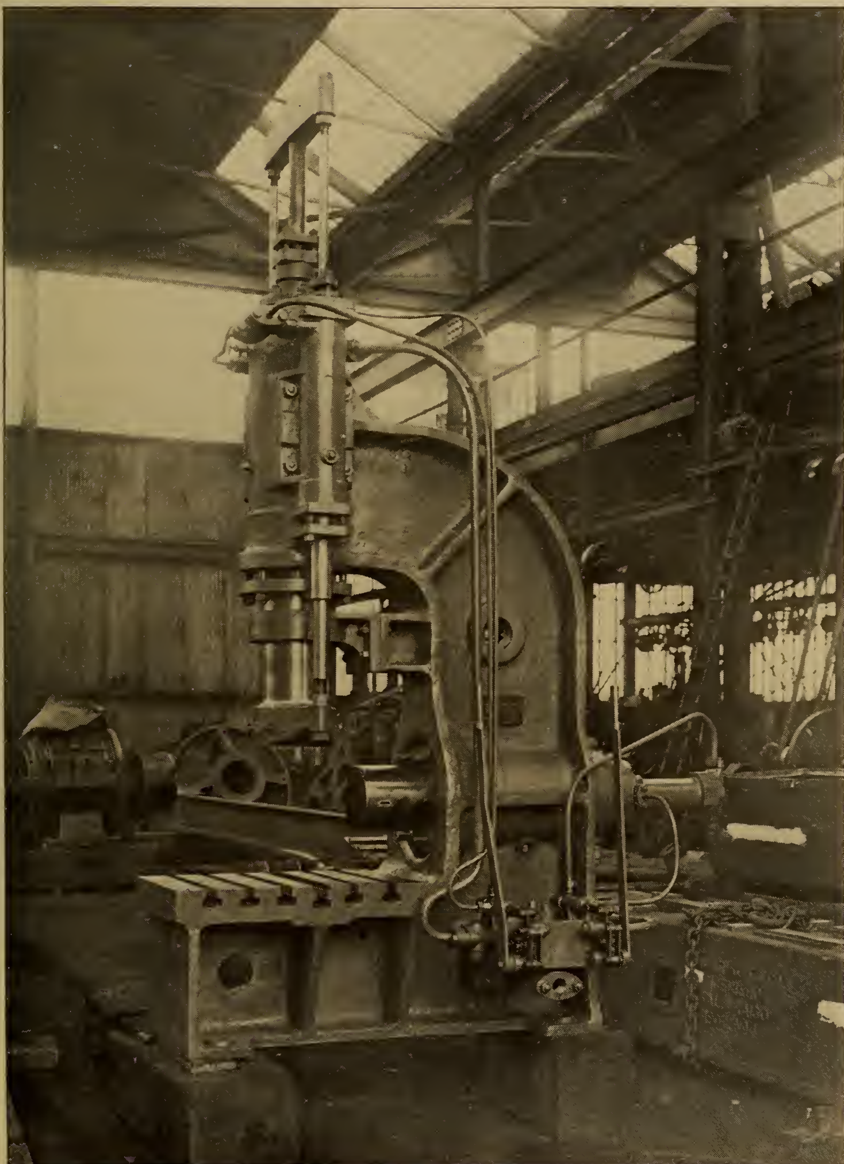



HYDRAULIC FORGING AND WELDING PRESS. HENRY BERRY & CO., LTD., LEEDS

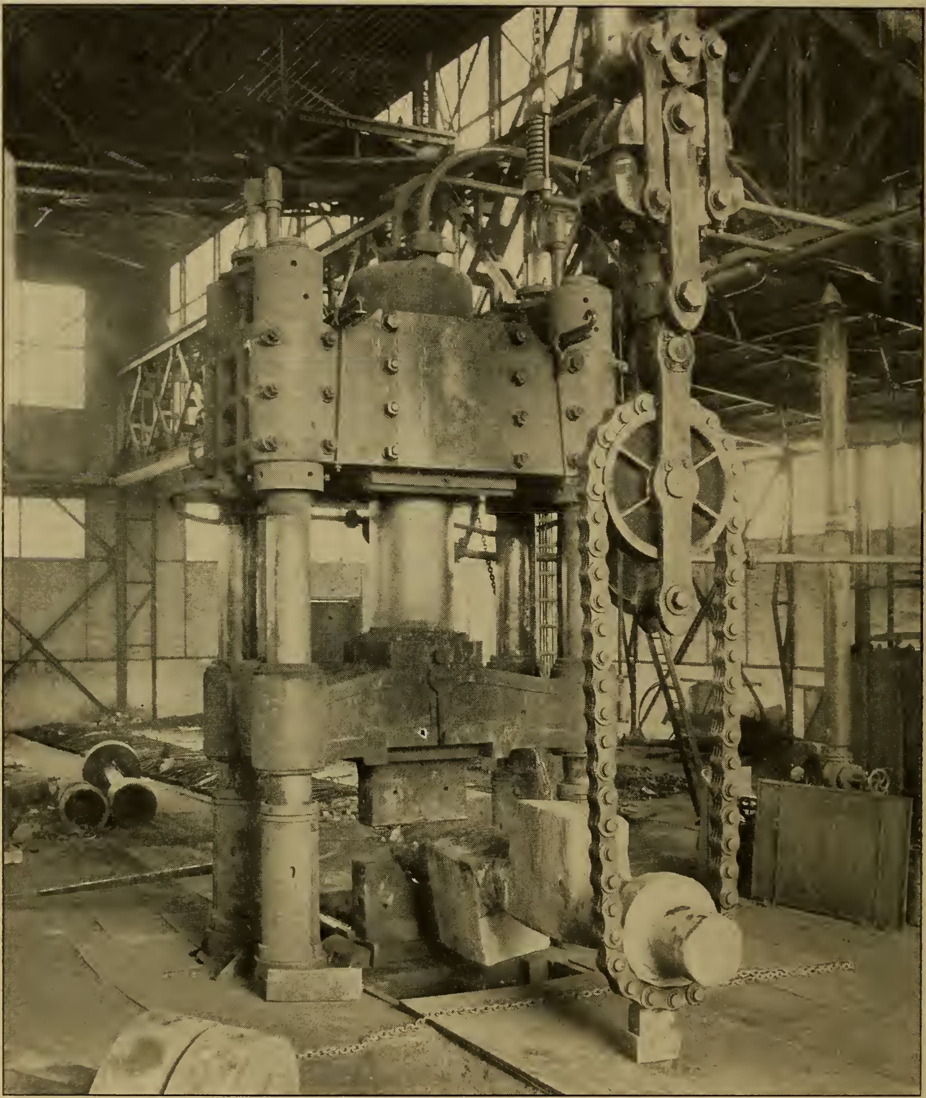



HYDRAULIC PUMP. ROBERT MIDDLETON, LEEDS, ENGLAND

valve contains six large main cylinders, with six additional pull-back cylinders, and the automatic features of the valve make it possible to operate the machine four times a minute, including the time of taking the work in and out of the machine. Smaller machines are controlled by similar valves, so that they can be operated eight to nine times per minute. The speeds of hydraulic presses depend upon the pressures available, on the valve and pipe openings, and on the resistance against the force on the hydraulic piston. Hydraulic presses for hot forging require greater speeds than most ordinary hydraulic presses, and hence larger valves are used for this service than in usual practice. Plunger speeds of 2 feet per second



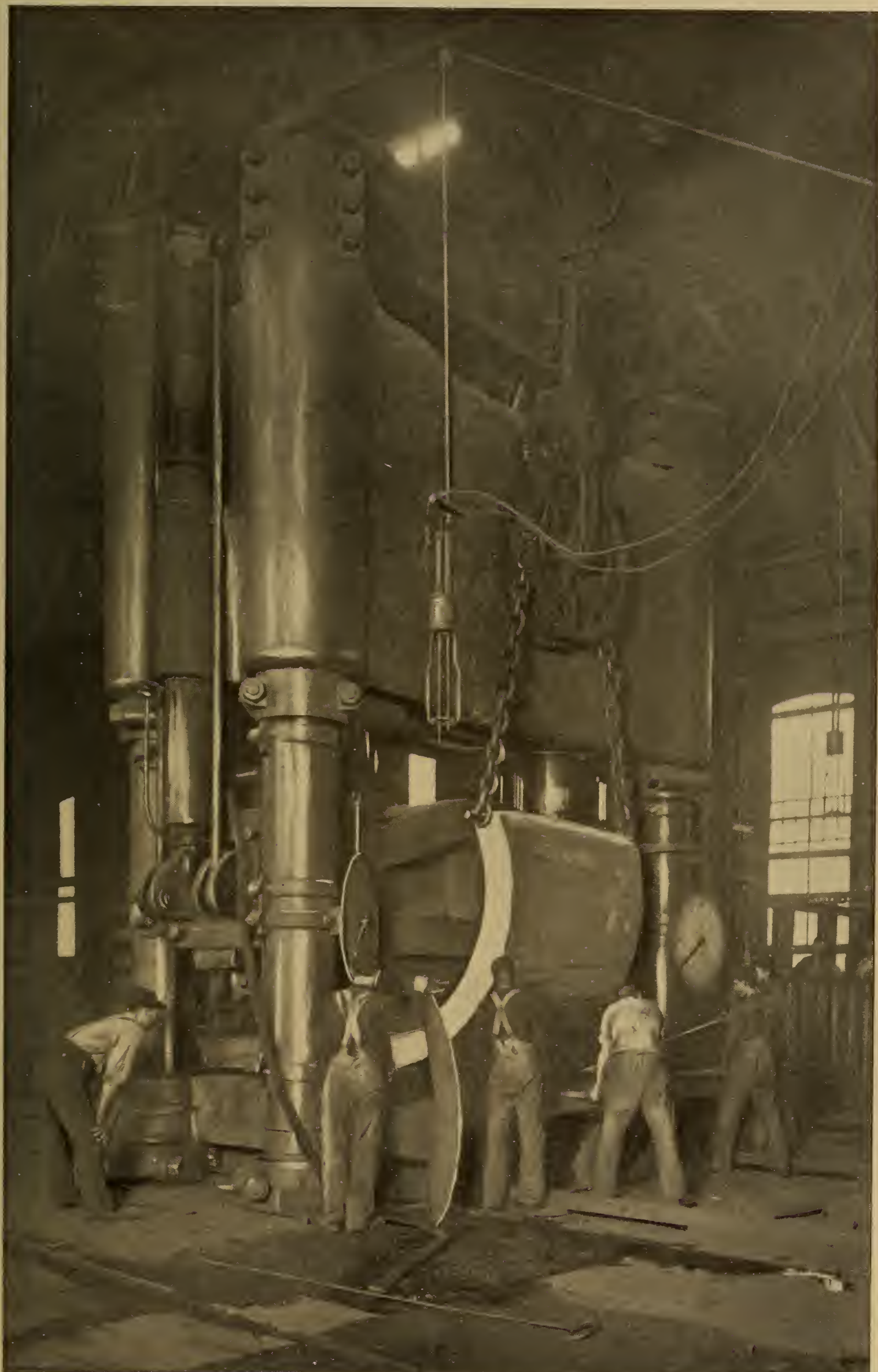
VERTICAL OPEN SIDE HYDRAULIC FLANGING PRESS. LEEDS ENGINEERING AND HYDRAULIC CO., LTD.



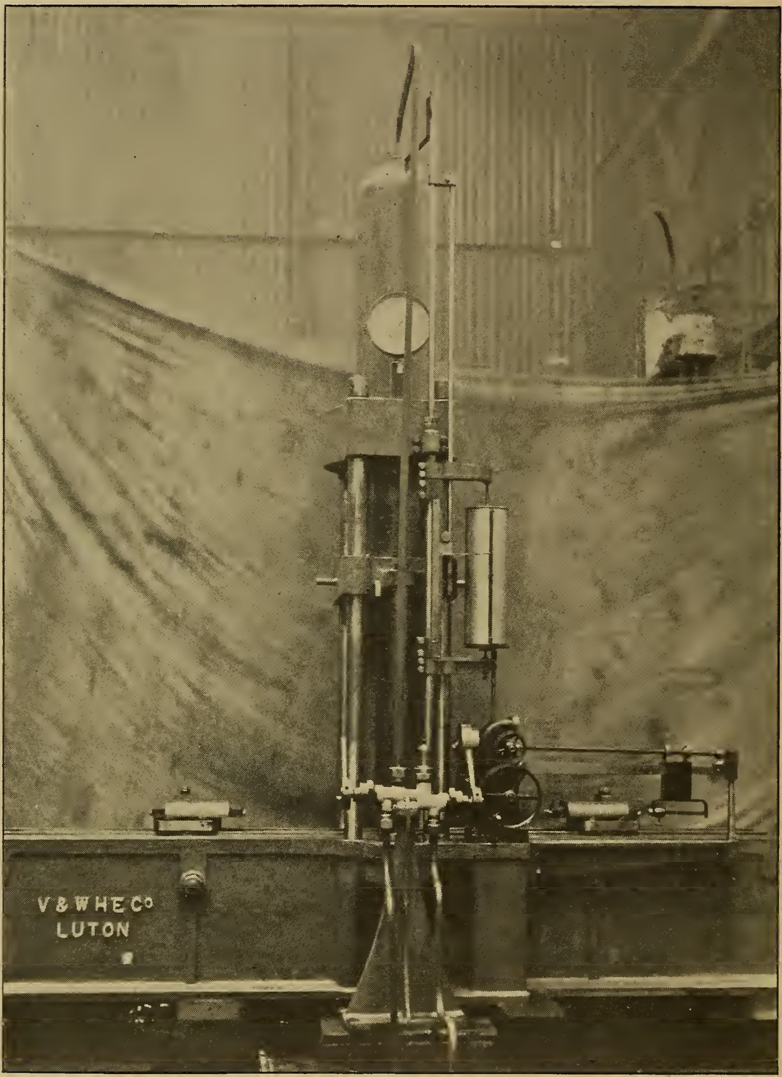
CRANK-SHAFT FORGING PRESS AT THE GUTEHOFFNUNGSHUTTE, GERMANY

are often attained in hydraulic forging presses for the manufacture of projectiles, hollow billets, etc., this speed being that actually effected when performing the work. Hydraulic presses are now taking the place of steam hammers for heavy forgings, and presses built for this purpose attain a great number of strokes per minute. Such presses are sometimes operated from low and high-pressure accumulators, but more frequently by use of steam intensifiers.

In the illustrations there are shown a number of hydraulic presses adapted for various kinds of work. Among these may be noted an armour-forging press, as used at the famous Krupp Works, at Essen, the forging press having almost entirely superseded the steam hammer for this kind of work. Another German press shown is that used at the Gutehoffnungshütte for forging crankshafts. Hydraulic



AN ARMOUR-FORGING PRESS AT THE KRUPP WORKS




HYDRAULIC SPRING TESTING MACHINE. VAUXHALL & WEST HYDRAULIC ENGINEERING CO., LUTON, ENGLAND

presses are also used for forming and shaping sheet metal, an example shown being that for making seamless metal boats.

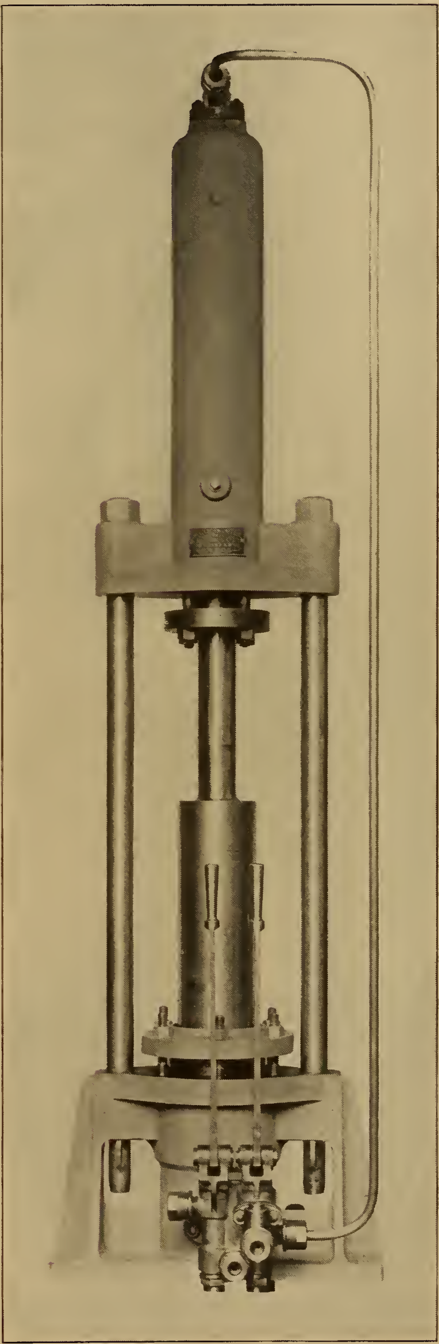
Many forms of testing machines employ hydraulic power for the application of the force, using various devices for recording the actual pressure applied. An example of such a machine is shown in the case of the apparatus for testing and measuring the deflection of springs under various pressures, this especial machine being made by the Vauxhall & West Hydraulic Engineering Company, of Luton, England. Presses are also used for bending and shaping, and among the illustrations will be seen machines for bending copper pipe and for general bending and straightening, these being by the Leeds Engineering & Hydraulic Works.

An interesting application of hydraulic pressure to a special article of

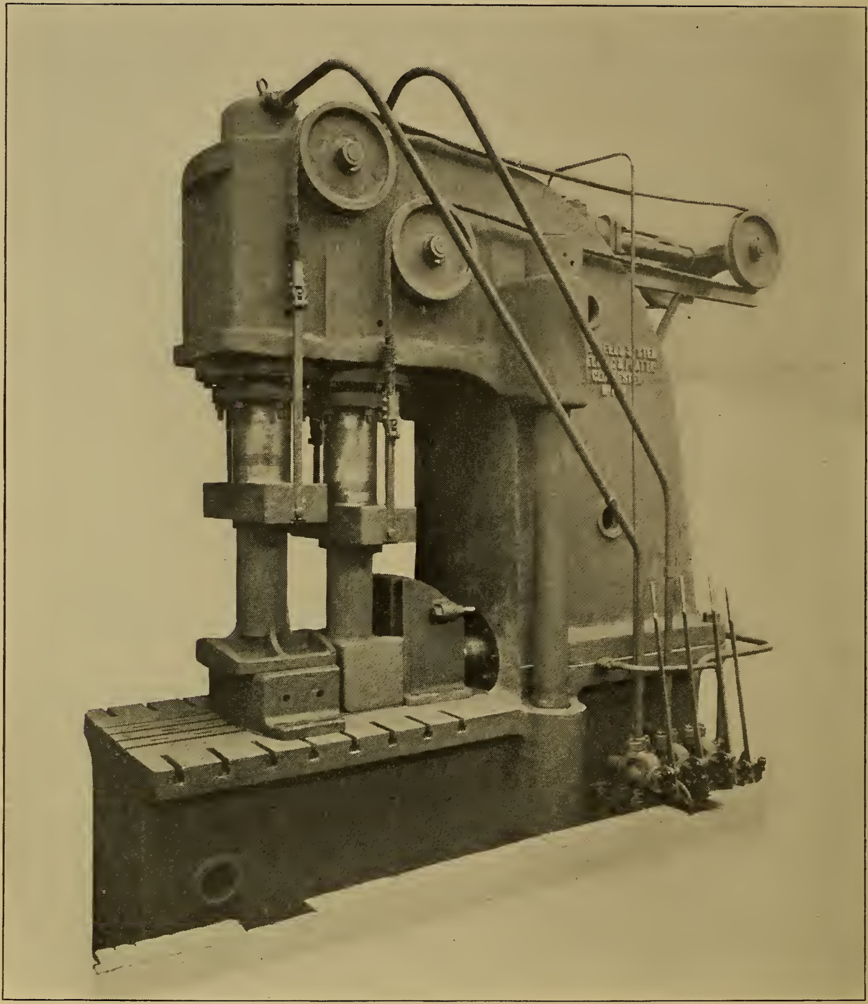
manufacture appears in the manufacture of disc records for the gramophone, and a battery of such presses, made by Robert Middleton, of Leeds, is shown in one of the illustrations. In these machines both the tops and the tables are heated by steam.

In addition to the application of the hydraulic press for heavy forging, machines of this type are now being extensively employed in place of the drop or steam hammer for the production of forgings in dies, both for heavy forgings and for cold die-sinking and coining, etc. The hydraulic press has many advantages for work of this kind, especially in view of the modern development of standardization of parts, rendering the use of dies applicable. In such work the individual skill of the smith is rendered unnecessary, and the preliminary work of drawing down, welding, bossing, and the like, is largely avoided. With the use of the forging press these preliminary operations involve the use of one or two movements, and very often a single operation is sufficient.

A similar line of work appears in the wide application of the hydraulic flanging press for boiler work and for heavy sheet-metal work generally. Some of these machines have a single cylinder; but it has been found practicable to arrange them with several cylinders, and thus extend their capabilities to a great extent. Among the illustrations will be seen machines of this kind having two vertical cylinders, as well as one horizontal one, this enabling the operation of flanging to be effected upon a variety of work without requiring the use of special and expensive dies and moulds. The operation of such a machine is as follows: The plate is placed on the segmental block and held firmly in place by the ram of the outer vertical cylinder, after which the descent of the inner ram turns down the plate. This operation may be repeated until the desired length has been turned down, after which the inner ram may be raised and the



VERTICAL HYDRAULIC INTENSIFIER
LEEDS ENGINEERING AND HYDRAULIC CO.

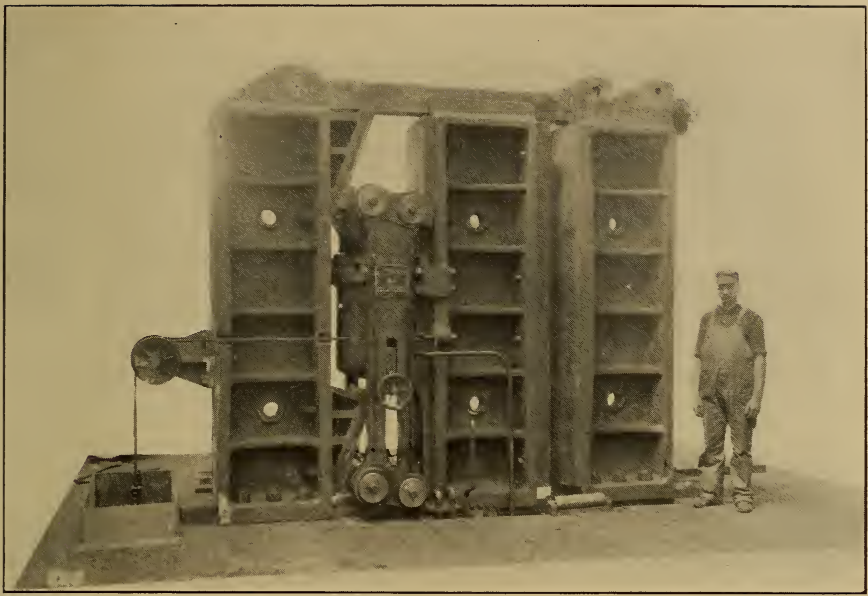


HYDRAULIC FLANGING MACHINE. FIELDING & PLATT, GLOUCESTER, ENGLAND

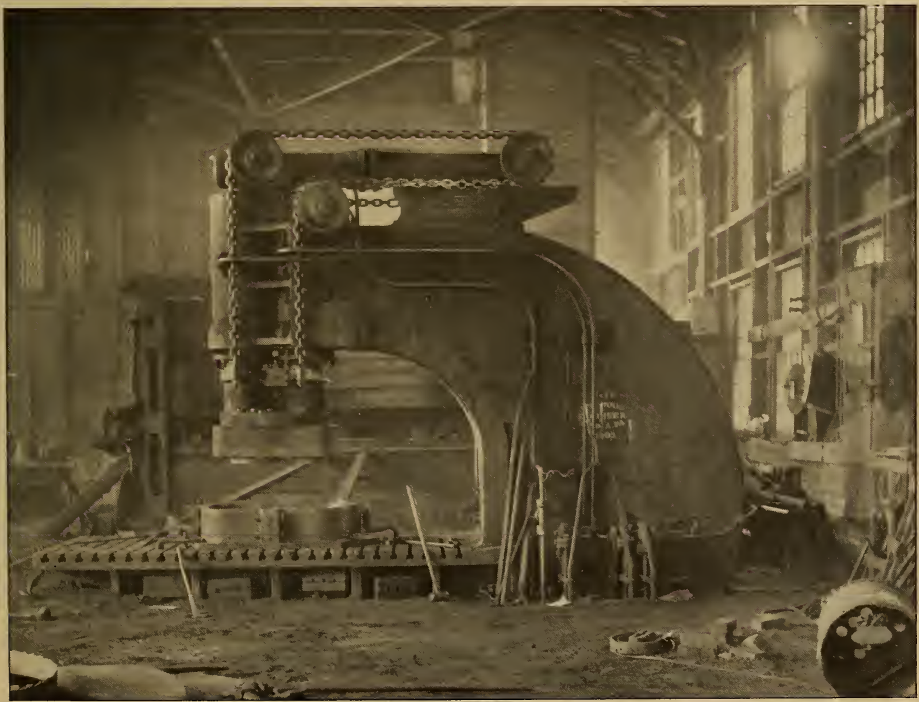
flange squared up by the action of the horizontal ram. When extra power is required for flanging dome-ends, furnace mouths, etc., the two vertical rams can be coupled to act together. Machines of this kind, both by American and British builders, are shown, and their wide capabilities will be apparent upon examination.

In the manufacture of steam boilers the use of hydraulic machinery has rendered practicable many operations otherwise most difficult to be done.

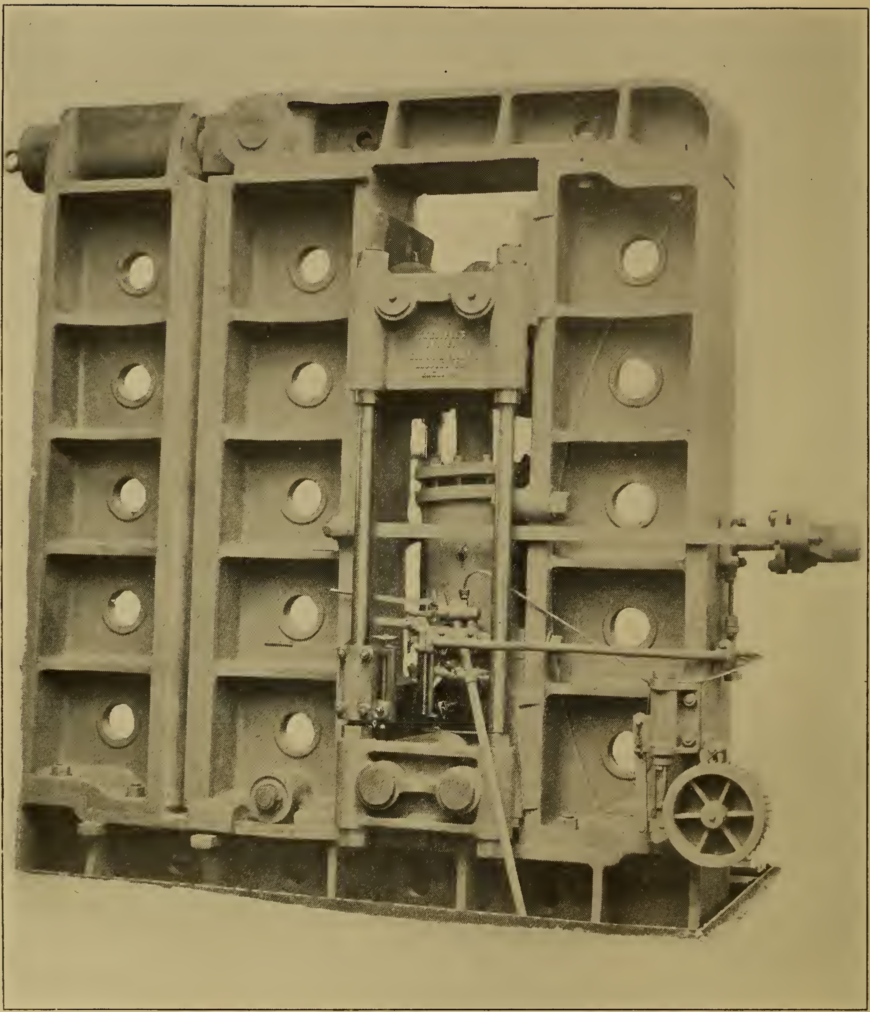
Thus, the heavy plates required for the shells of large cylindrical marine boilers are more readily and accurately bent in hydraulic presses than in the rolls formerly used. Two examples of this machine are shown, one by Messrs. Fielding & Platt, of Gloucester, England, and the other by Messrs. R. D. Wood & Co., of Philadelphia. In general design the machine consists of three vertical platens or girders, the two outer ones being bolted down to a heavy bed-plate and tied together at the upper ends by a hinged tie bar, this latter being lifted to allow of the removal



VERTICAL SHEET BENDING PRESS, 200-TON CAPACITY, FOR PLATES 9 FEET 3 INCHES WIDE, $1\frac{3}{4}$ INCHES THICK. R. D. WOOD & CO., PHILADELPHIA



HYDRAULIC SECTIONAL FLANGING PRESS. WM. H. WOOD, MEDIA, PA.

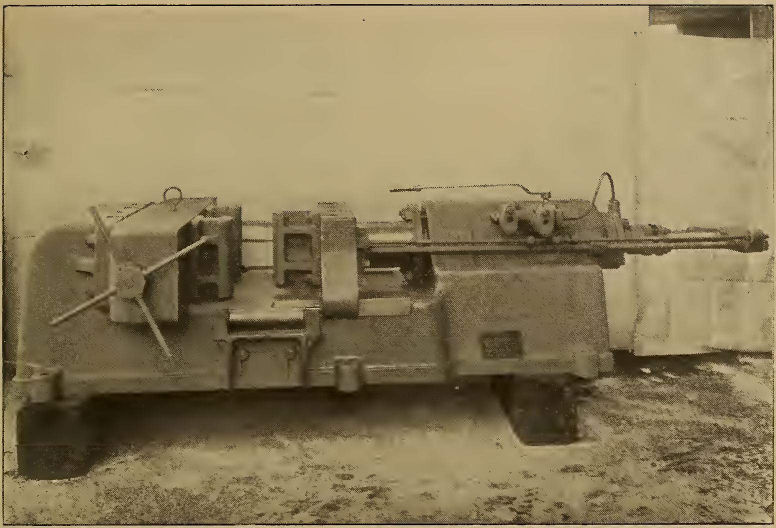


TWEDDELL HYDRAULIC BOILER-PLATE SHELL BENDER. FIELDING & PLATT, LTD. GLOUCESTER, ENGLAND

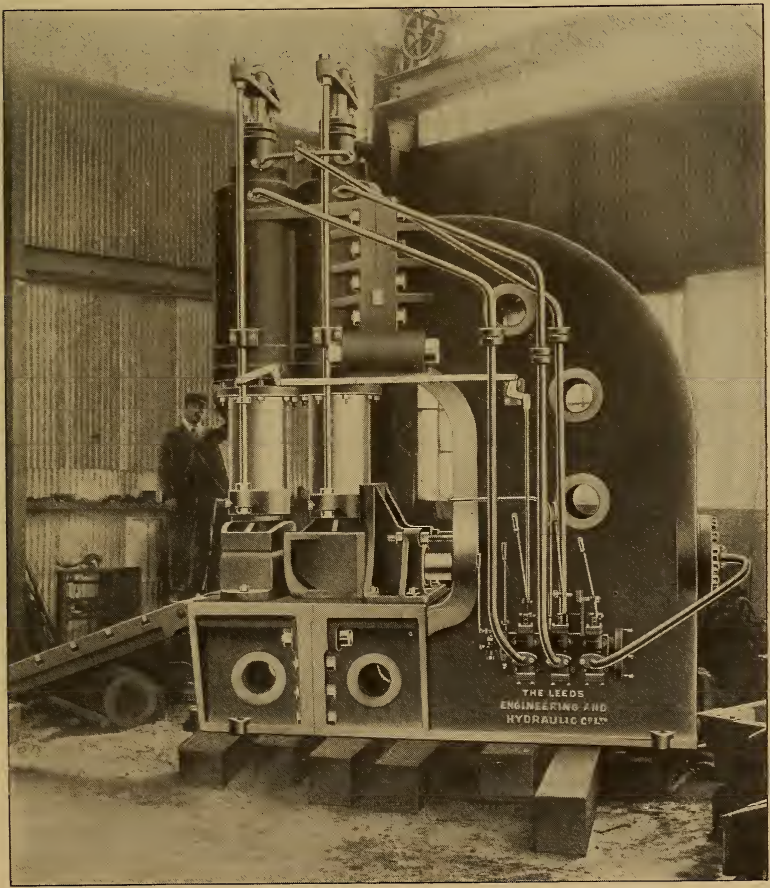
of the bent plate from the machine.

The middle platen is free to move, and is operated by the vertical ram acting upon the inclined planes through rollers, a parallel movement being thus effected. The movable platen is made with a concave face opposing a convex face upon the fixed platen, and, by controlling the movement, a plate may be bent to any desired curve without the use of special dies. With these machines the plate can be bent to a true curve out to the very edge, a feature which cannot readily be accomplished with the ordinary plate-bending rolls. Machines of this kind are capable of bending boiler plate as thick as 1⅝ inches, and they are now used in many of the large ship and engine-building establishments of Europe and America.

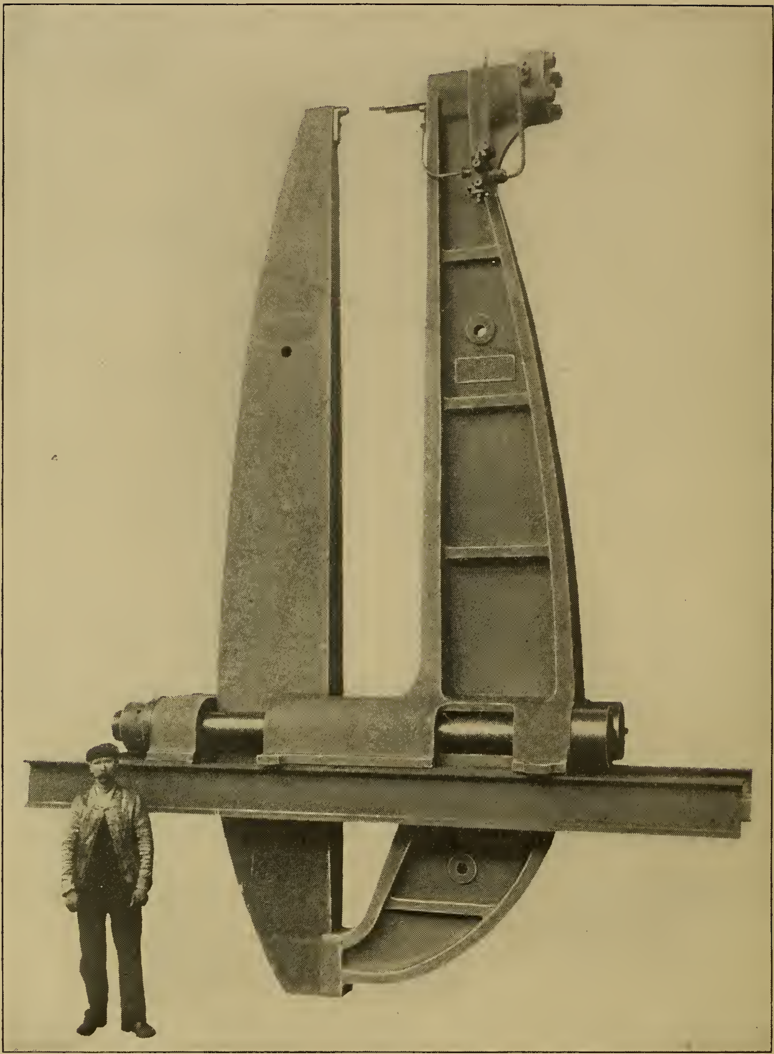
Hydraulic rivetting machines have been used for many years; but their size, capacity and speed have continually increased. Two general types are shown, one being the vertical fixed machine, in which the pressure



HYDRAULIC BENDING AND STRAIGHTENING PRESS. LEEDS ENGINEERING AND HYDRAULIC WORKS, LTD.




HYDRAULIC FLANGING PRESS. LEEDS ENGINEERING AND HYDRAULIC CO., LTD.

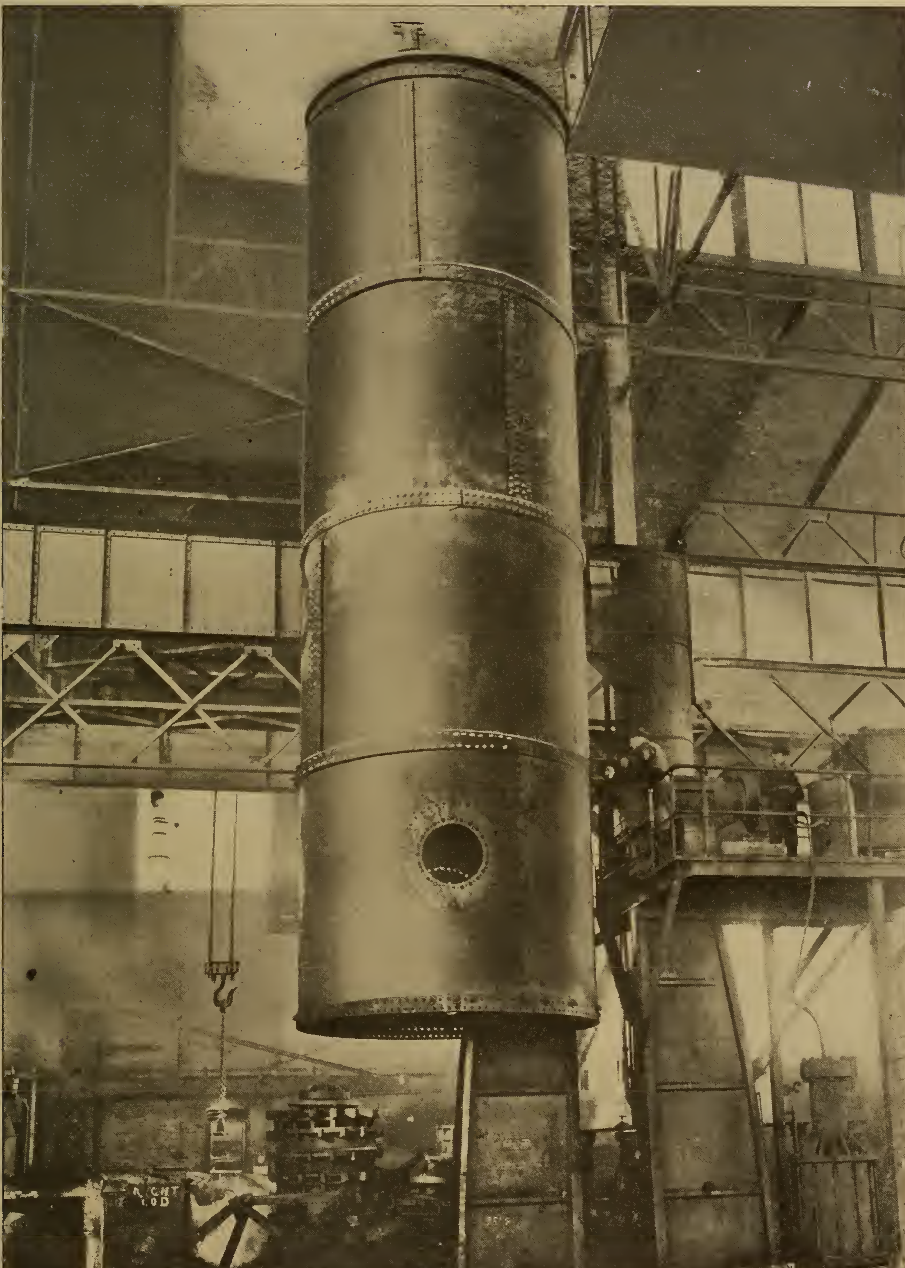


LARGE FIXED RIVETING MACHINE. RICE & CO., LTD., LEEDS.

is exerted against a stake, the boiler shell being suspended from above. These machines are used for such large work as can be brought to them, an interesting example being seen in the rivetting of a section of the shell of a penstock for the Niagara Falls power development at the works of the Canada Foundry Company, the rivetter having a gap of more than 18 feet, and being built by Wm. H. Wood, of Media, Pa.

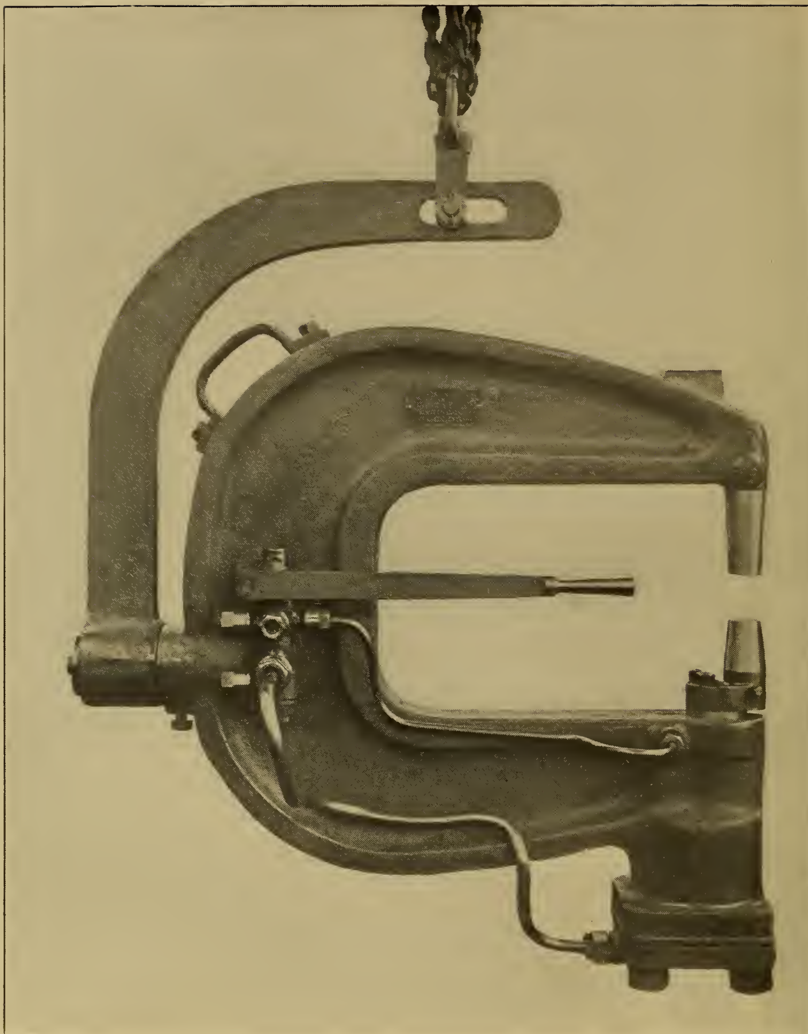
Portable hydraulic rivetting machines are usually made to be suspended from the hook or a hoist or crane and this readily brought to the point of operation, and they are extensively used both in boiler work and in structural and bridge work. In some forms the hydraulic ram acts directly upon the rivet head, and in others the pressure passes through a system of levers.

The illustrations show various methods of suspension, the ease of handling, and hence the rapidity of




RIVETTING A SECTION OF NIAGARA FALLS PENSTOCK ON HYDRAULIC RIVETTER BY WM. H. WOOD, MEDIA, PA., AT THE CANADA FOUNDRY COMPANY'S WORKS, TORONTO

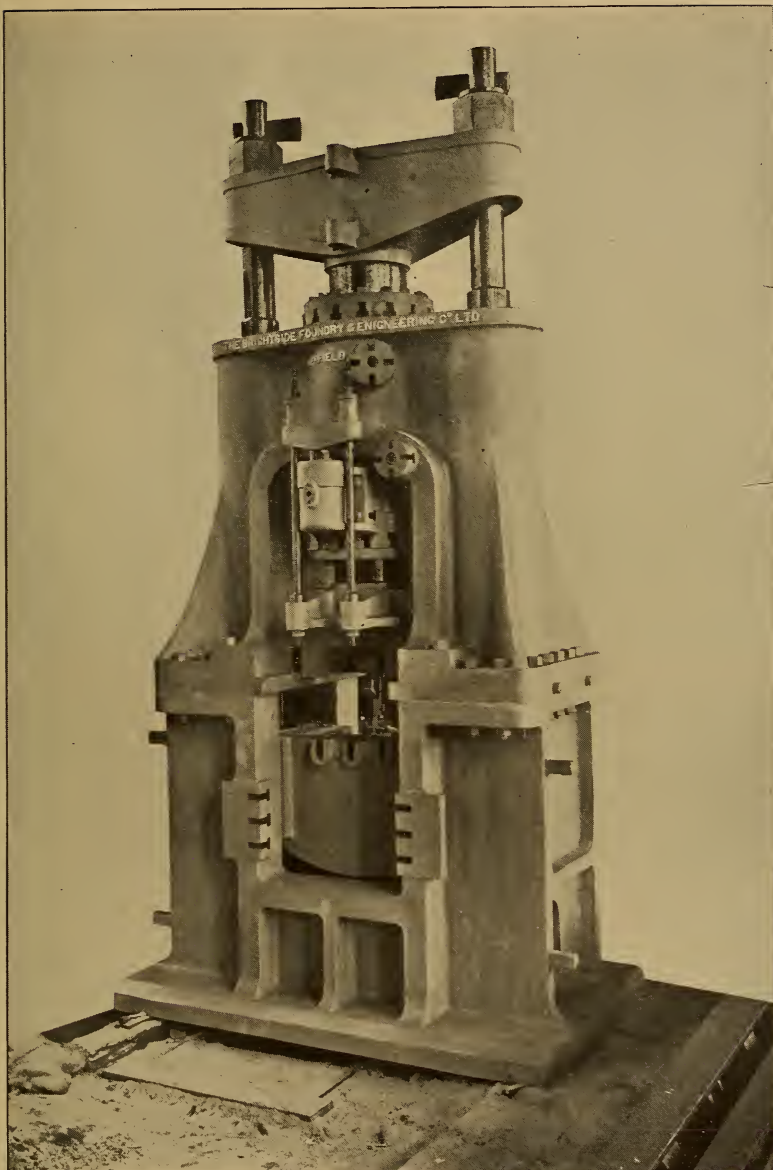
The penstock sections were 35 feet long and 10 feet 6 inches diameter, made of plates $\frac{3}{4}$-inch thick. The gap of the rivetting machine was 18 feet 6 inches.



PORTABLE BEAR TYPE HYDRAULIC RIVETTER WITH BOW HANGER
LEEDS ENGINEERING & HYDRAULIC CO., LTD.

work, requiring especial attention in this detail.

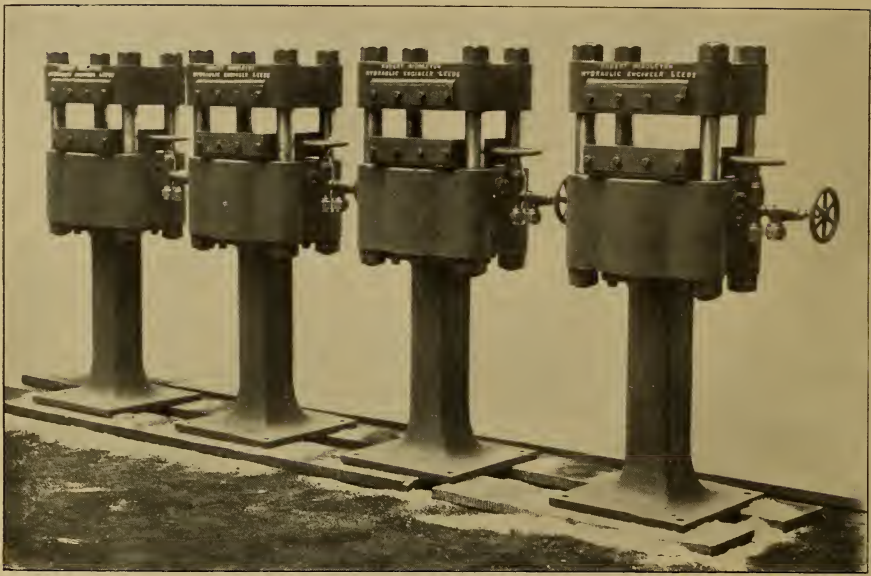
Another hydraulic tool for use especially in the railway shop is the wheel press, and with the general use of forcing fits, both for car wheels and for other portions of engine work, the forcing press has become an established feature. The press made by the Brightside Foundry & Engineering Company, of Sheffield, is shown complete with its own pressure machinery, including a set of electrically-driven, three-throw pumps, having a water tank in the main frame to supply the pressure cylinder, and into which the water is returned on the in-stroke, which is effected by means of a balance weight attached to the ends of steel wire ropes. The press and the movable headstock are supported on two channel bars, these acting only as supports, the stress being taken entirely by two round steel tension bars having grooves turned in them to en-



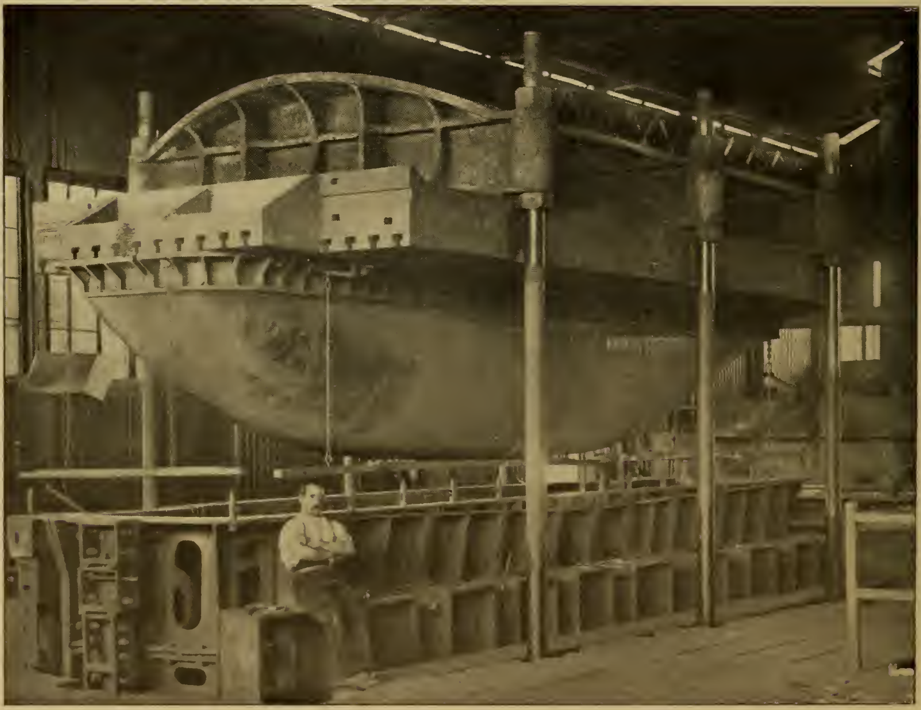

HYDRAULIC BLOOM SHEARS. BRIGHTSIDE FOUNDRY & ENGINEERING CO., LTD., SHEFFIELD

gage with suitable resistance blocks at the back of the adjustable cross-head. Forcing presses of this kind, varying in detail, are in very general use, both for assembling work and for removing wheels, cranks and similar parts when necessary.

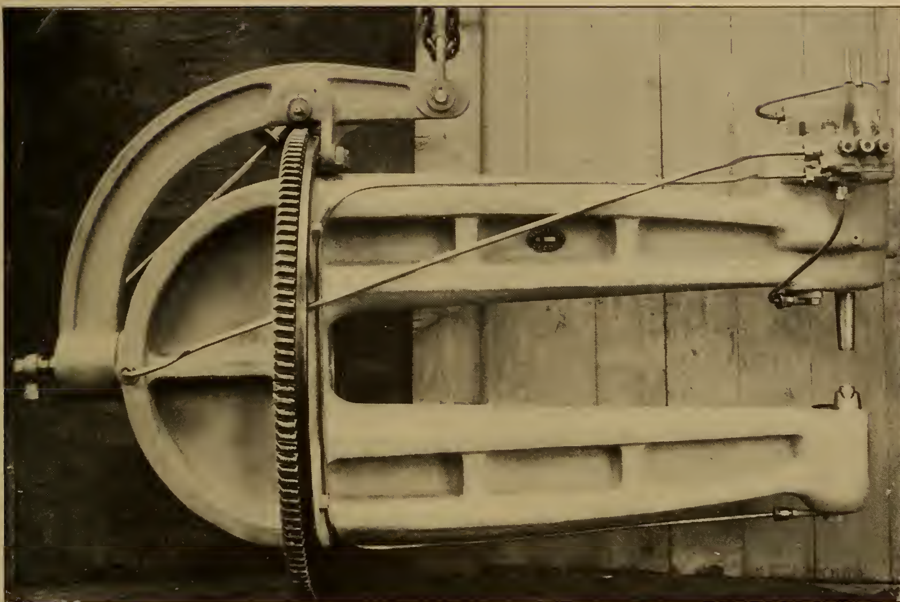
In a previous paper there was shown an illustration of a hydraulic shear designed for splitting steel plates. The valve arrangement of this machine allows the shear to run continually, or to make one revolution and then stop, at the will of the operator. A great advantage of this type of machine is that the slide sup-



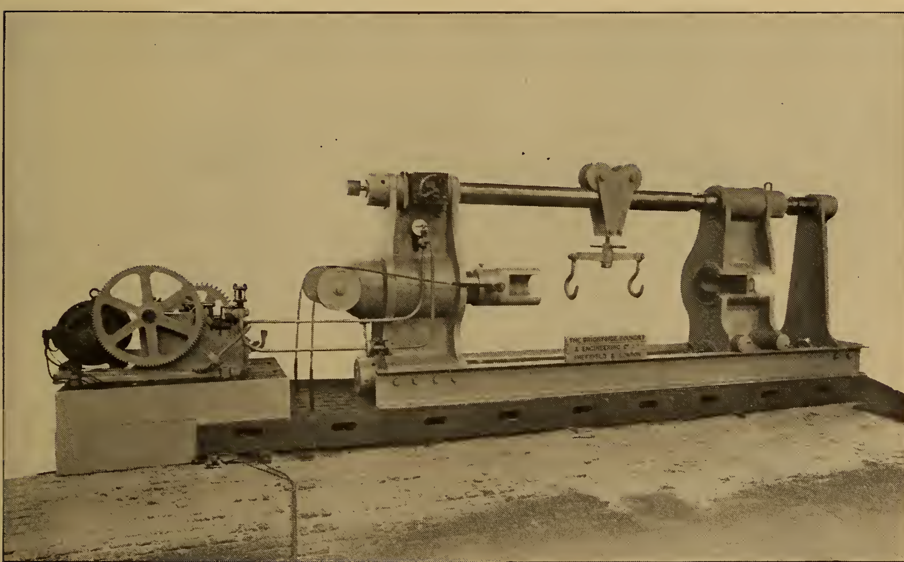
PRESSES WITH STEAM-HEATED TOPS AND TABLES FOR PRODUCING GRAMOPHONE DISC RECORDS
ROBERT MIDDLETON, LEEDS



HYDRAULIC SEAMLESS BOAT PRESS. HENRY BERRY & CO., LTD., LEEDS, ENGLAND

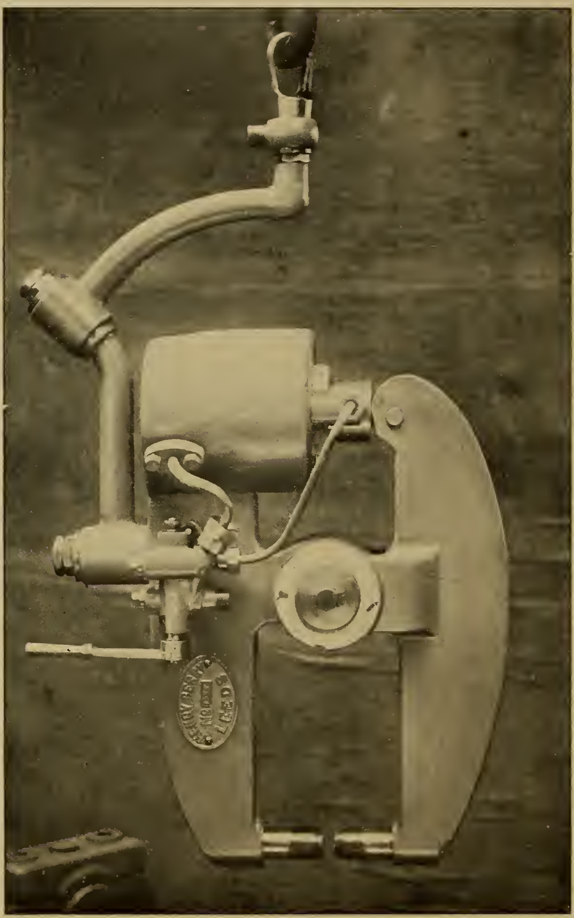


PORTABLE HYDRAULIC RIVETTER, MERIDIONAL TYPE. HENRY BERRY & CO., LTD., LEEDS, ENGLAND



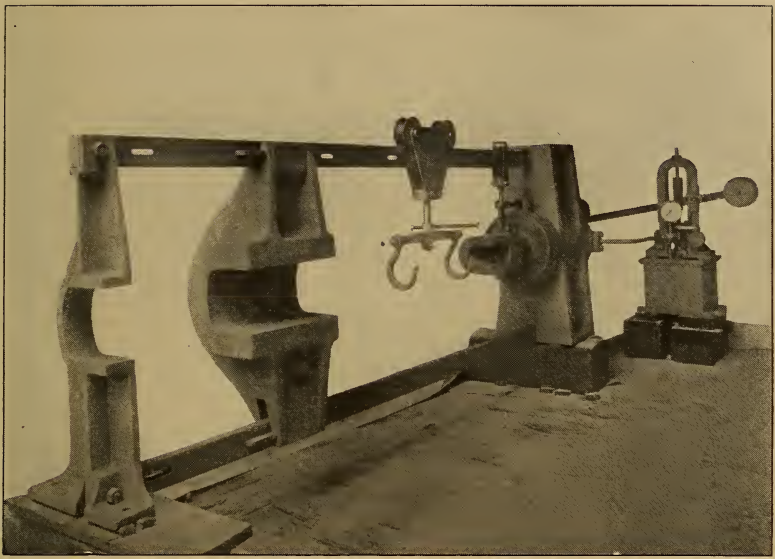
HYDRAULIC WHEEL PRESS. BRIGHTSIDE FOUNDRY AND ENGINEERING CO., SHEFFIELD

porting the upper cutter can be stopped or reversed at any point of the stroke, thus permitting an inside curved edge to be sheared. A special example of hydraulic bloom shears of the up-cutting type is illustrated, this being made by the Brightside Foundry & Engineering Company, and capable of cutting blooms 12 by 10 inches, or 20 by 6 inches. In this machine the ram of the cutting cylinder is connected to the bottom knife block through a massive crosshead and two tension bolts, the latter passing through machined guides in the main frame. The top knife block is carried on the ram of an inverted hydraulic cylinder of the same diameter as the cutting ram, and this enables the top knife block to be adjusted to suit any required thickness of bars to be cut without any undue travel of the ram. The bottom block descends by gravity, and the top knife block ram is returned under constant pressure.

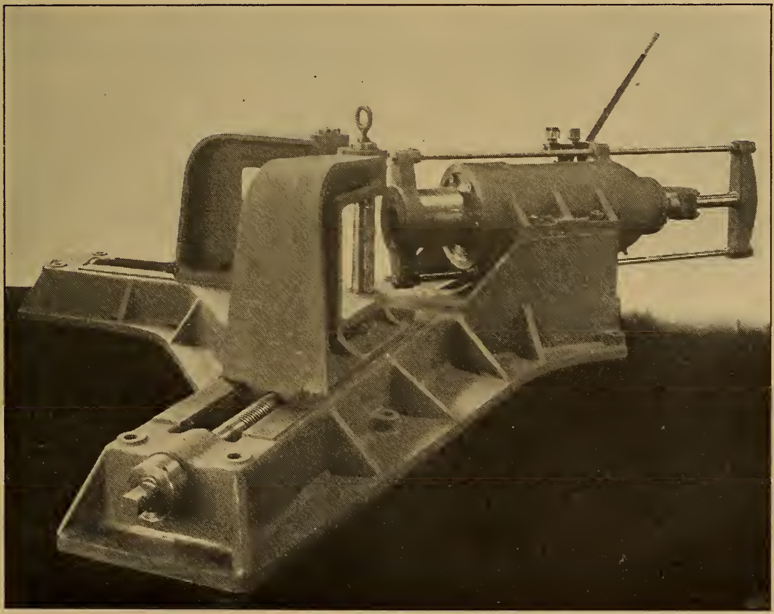


PORTABLE HYDRAULIC RIVETTER. HENRY BERRY & CO., LEEDS, ENGLAND.

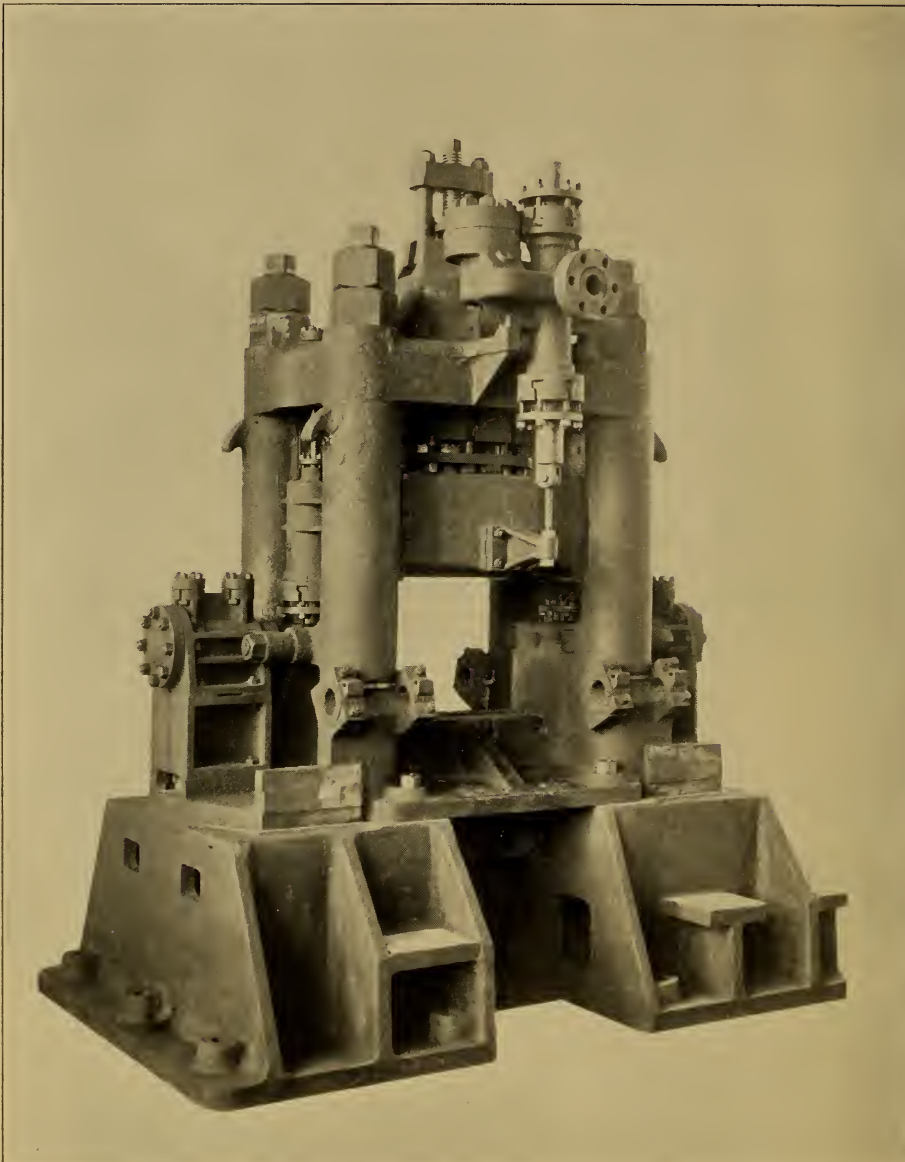
The hydraulic tools already referred to represent but a few of the important machines designed for various workshop operations. In the shipbuilding industry hydraulic machines are used for bending plates and frames, for punching holes, for shearing beams and girders, as well



HYDRAULIC WHEEL PRESS. LEEDS ENGINEERING AND HYDRAULIC CO., LTD.



BENDING PRESS FOR COPPER PIPE. LEEDS ENGINEERING AND HYDRAULIC CO., LTD

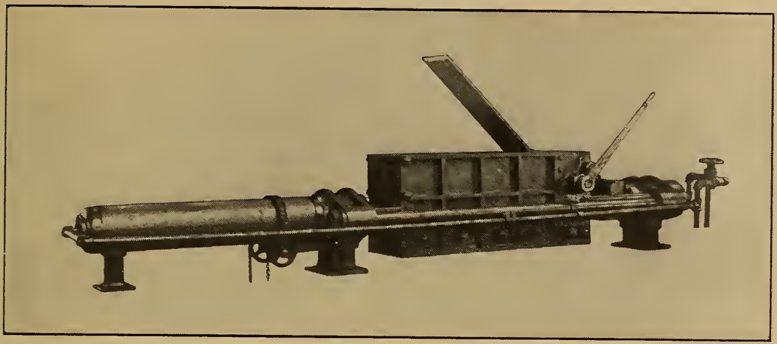


HYDRAULIC BEAM SHEAR. R. D. WOOD & CO.

as for closing rivets. The same is true of other departments of industry. Thus, in the manufacture of steel pipe for irrigation purposes a special form of hydraulic rivetter is made, with automatic spacing mechanism. In this work the rivets are entered from the outside, and the rivet heads are closed on the inside of the pipe. When the pressure is released the pipe is moved automatically to the next rivet, and so on.

Hydraulic power is also used for various drawing operations, such as the manufacture of seamless tubing of steel, copper or brass, as well as for the drawing of large shells.

An interesting application of the



150-TON HYDRAULIC BALING PRESS FOR STEEL, BRASS OR ALUMINUM SCRAPS
THE WATSON-STILLMAN CO., NEW YORK

hydraulic press is shown in a machine for baling sheet-metal scrap, being used for steel, copper, brass or aluminum scrap. The press illustrated is of 150 tons capacity, and makes a very compact bale of steel scrap, measuring 10 by 10 by 20 inches, weighing 250 pounds, in three to five minutes, the time depending upon the pumping equipment.

Another special use of hydraulic pressure appears in the manufacture of carbons for electric lamps, electric furnaces, etc. In this operation the loose carbon is rammed into a cylinder or mould opposite the hydraulic cylinder, and when the pressure is applied to the piston the carbon is forced out through a die in the carbon cylinder, the compressed carbon thus being delivered in the form of long sticks or rods. Similar presses are used for forming smokeless powder in rods or tubes, the operation being similar to that of the lead-covering press, which, by a heavy pressure on the lead, forces the metal out through a die and around the cable. The so-called extrusion process is another application of the same principle, bars of brass or aluminum of various sections being formed by pressure through dies.

In the preceding pages some attempt has been made to show the wide applicability of hydraulic pressure to mechanical operations, employing not only the original principle of the hydraulic press of Bramah, but the use of accumulators, intensifiers, and a multitude of detailed improvements, making the department of hydraulic machinery one of the most fertile branches of mechanical engineering. Space is not available to speak of many applications, such as the use of hydraulic pressure to the feed on cutting tools, as lathes, and similar machines, nor has the important field of hoisting machinery been touched, except in the limited case of the hydraulic jack.

Enough has been shown, however, to demonstrate the great technical and commercial value of hydraulic power in the development of engineering operations, a value which is continually increasing as improvements are made.

# Current Topics

THE importance of the pig-iron industry of the United States as a barometer indicative of general trade conditions is well shown in a diagram recently prepared by Mr. John Birkinbine, of Philadelphia, well known as an authority in this department of metallurgical engineering.

Taking the statistics of the American Iron and Steel Association and the data furnished by the Census Bureau of the United States Government, Mr. Birkinbine compares the population and the iron production of the United States in 1890 with the figures for 1907, showing the pig-iron valuation per capita during this period, together with the figures for currency circulation for the same time.

Thus, in 1890 the population of the continental United States was, in round numbers, 63 millions, while by 1900 it reached 76 millions, and in 1907 85½ millions, there being thus a gain of nearly 36 per cent. in 1907 over 1890. In 1890, according to the report of the Controller of the Currency, the currency circulation per inhabitant was $22.82, while in 1907 the circulation per capita had increased 41 per cent., or to $32.22, there having been a drop in 1896, due to the business depression of the preceding years.

At these same dates the domestic production of pig-iron, in long tons, was as follows: 9,202,703 tons in 1890 and 25,781,361 tons in 1907, an increase of 180 per cent. This increase was practically all in the actual domestic production, since the importations of foreign pig-iron and ferro-alloys during the eighteen years did not exceed three million tons, while the exports were more than one and a half million tons; and in no year did the foreign business affect the total more than 3½ per cent.

In 1890 the amount of pig-iron produced per capita was 327 pounds, while by 1907 it had more than doubled, reaching 675 pounds per capita, and the price of Bessemer pig per ton rose from $18.85 in 1890 to $22.84 in 1907, with fluctuations in the intervening years, dropping as low as $10.13 in 1897. Multiplying the production of pig-iron per capita by the average price per ton gives the percentage of currency circulation represented by the industry.

Thus, in 1890 the blast furnaces of the United States made 0.15 ton per capita, of which the average price was $18.85 per ton, corresponding to $2.76, or more than 12 per cent., of the total per capita circulation for that year. In like manner we find that the per capita production of pig-iron in 1907 represented a value of $6.87, or more than 21 per cent. of the currency circulation.

As Mr. Birkinbine remarks, this

proportion is indicative rather than real, since the same money is used repeatedly during the year, and it is subject to modification because of the variations of prices in different parts of the country. The figures demonstrate, however, the importance of the pig-iron industry as a barometer of trade, and if the amounts and values of finished iron or steel products were considered, the proportions of the circulation per capita would be still greater.

Briefly, during the period of eighteen years under consideration the population of the United States increased about 36 per cent., and the domestic pig-iron output was nearly trebled, the increase per capita being doubled. While the available currency per inhabitant had increased 41 per cent. in this time, the pig-iron industry demanded in 1907 nearly two and one-half times as much money as in 1890.

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EXPERT testimony in connection with trials and investigations involving technical questions must always be necessary, since it is impossible to assume that men who have had to devote the greater part of their energies to the acquirement of the law san also have qualified themselves to pass upon matters of theoretical and applied science as well. The result is the development of a branch of scientific work devoted to the explanation of technical operations and relations to courts and juries, a department of technical science which has numbered among its exponents some of the ablest and most brilliant scientists of Europe and America.

It cannot be denied that some of the methods which have become associated with the use of expert testimony have been made the subject of severe and adverse criticism, and it is generally admited that this fact is largely due to the practice, now generally obtaining, of permitting each side in a controversy to retain its own experts, thus making them, to a certain extent, advocates in the service of those by whom they are employed. Under such circumstances the ablest men may be engaged in the support of the side of a question not wholly in accordance with their fullest convictions, while it is also possible for a wealthy contestant to retain the principal specialists in a subject, simply to prevent their employment by his adversary.

For some time a remedy for this state of affairs has been suggested, the plan being to place the matter of expert testimony in the hands of the court; the scientific witnesses to be free from any especial allegiance to either side, and their fees to be paid as a part of the costs of the hearings.

This idea has been brought into prominence recently in connection with the question of medical expert testimony, and the plan has been advocated, in part, at least, by two such important professional bodies as the State Medical Association and the State Bar Association of New York.

The plan proposed in the case of medical experts is the establishment of a body of experts, officially recognized as those from among whom witnesses may be selected by the courts, or chosen by agreement of the contestants, to investigate the facts and present a written report to the court, this report forming a portion of the evidence; the experts by whom it has been prepared being also liable to be called for further examination and interrogation. Such experts, being employed by the court, are presumably freed from any allegiance to the interests of either party, and placed in a position of complete independence, an arrangement which should be most welcome to the scientific specialist whose entire training has been that of a seeker after truth.

In the case of medical experts there are a number of questions

to be considered which render the matter a difficult one to bring into full effect, but it appears most desirable that some such method should be arranged in connection with the procuring of expert opinions in matters of engineering in legal controversies. The development of engineering in certain branches has been so rapid during recent years that it is practically impossible for the latest state of the art to be embodied in books of reference, while the magnitude of the commercial interests involved in industries based upon patented inventions and the like, renders it most important that the facts in question be ascertained completely and impartially, regardless of the individual interests at stake.

In nearly every department of engineering there are men generally conceded to be specialists whose opinions represent the latest scientific knowledge in their respective fields. These men should be freed from the possibility of the suspicion of bias, and should be enabled to give to the community, in return for fees comparable to those paid for similar services in other departments of scientific work, the fruits of their knowledge towards the administration of justice. This most desirable end may be attained by just such a plan as that which has been proposed for the regulation of medical expert testimony. Let the experts be called by the court, let their absolute independence of either party to the suit be made essential to their employment, and let them make a broad report to the court upon the whole state of the matter under controversy, so far as its relations to applied science in its latest developments are concerned. That this system is desirable few will deny, that it is practicable may soon appear, if the effort of the physicians and lawyers of New York be put into actual operation and give satisfactory demonstration of its advantages for the engineer as well as for the doctor.

ENGINEERS interested in the application of electrical motors to machine tools might be well advised to read a recent article by Mr. Vernon in the "Engineer." It deals with the question of the power of machine tools, particularly of heavy tools, which are by no means supplied with that amount of power that might be, and often is, inferred from the weight of the machine. And every man who has engaged in workshop practice knows only too well that the heavy machine tool has often proved to be possessed of singularly small powers of removing metal. Weight—the mere principle of the anvil—is an excellent quality in tools; but it is of very little use putting in weight unless there is corresponding cutting power to bring that weight into service for the purpose it is supposed to be intended. One common fault has been that the belt has been altogether insufficient. It does not matter that a belt is narrow if it only travels fast enough, nor does it matter much that it travels slowly, if only it is wide enough. Both these factors of width and of speed come into the power account on the same basis of their first power in all ordinary conditions. The quantity that tells is their product, or the number of square feet of belt surface which passes a given point in unit time. This should be some 10,000 square inches per horse-power per minute, according to Mr. Vernon, and it appears to be about right.

But, granting the sufficiency of the belt per intended horse-power, the prime question is: Is there sufficient horse-power? Considerable has appeared in various papers and proceedings on the power necessary to cut metal, and undoubtedly such power can best be got in a machine tool by means of a built-in electric motor. But engineers who have at heart the interests of electric driving should be very careful how they draw conclusions from the best power they may find on existing machines. Where possible, when a machine tool

is found to be taking a heavy cut satisfactorily, the area of the cut should be noted, together with the surface speed of the work at the radius of the cut and the passing; but area per minute should be found from the pulley speed and diameter. In very many of the newer tools that have been brought out since the merits and possibilities of the high-speed steels have become recognized by the tool builders much more ample provision of belt power has been made. The cheap merchant lathe is a particularly flagrant offender in the matter of insufficient belt power, and plenty of other machines in the past were little better.

The electrical drive gives great opportunities of getting more out of a tool and justifying the heavy weight, which too often has been made to stand for power. The question of a powerful motor is one of prime importance and should not be neglected.

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MINES and Minerals of Scranton, Pa., has been calling attention to the curious fact that in coal-mining communities there is a marked deficiency in the mortality from tuberculosis as compared with that of other localities. This is a phenomenon that has also been observed in Great Britain, and attention has been drawn to it by Mr. B. H. Thwaite. Writing to "Mines and Minerals," Mr. W. H. Booth draws attention to Mr. Thwaite's investigations. According to Mr. Thwaite the effects noted may be due to the physiological effects of carbon monoxide, for he finds that men engaged about blast furnaces and gas producers are peculiarly free from tuberculous trouble. It is suggested in "Mines and Minerals" that the presence of carbon dust in the lungs may be a cause of production of CO, and that this will serve to explain the immunity from the disease of miners. The tubercle bacillus is a creature of extreme tenacity of life. It is encased in a waxy integument and is proof against even nitric acid, but gases are so penetrating in their powers of diffusion that it can well be considered that carbonic oxide might reach the tissues of a creature in a subtle manner, for the gas cannot be perceived. Against nitric acid the creature might close itself up. Against an unperceivable but poisonous gas it would get no manner of warning. There certainly seems to be a sufficient amount of fact to justify a thorough enquiry into this possible connection between absence of tuberculosis and presence of CO, or carbon.

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THERE has developed a tendency during the past few years to regard much of the expenditure on steam valves as excessive. This expenditure has been made worse by the employment of the ring main steam pipe, which seems to be a device specially contrived for the sole benefit of valve manufacturers.

The loss of pressure in any steam pipe is largely a matter of skin friction, and this is a function of length and velocity. If velocity be increased, the resistance due to skin friction will be increased. If a pipe be assumed of a length of 100 feet, and if for 1 foot of that length the friction be doubled, there will only be an increased percentage of total friction of 1 per cent. Taking this fact into consideration, it was suggested by W. H. Booth, in his book on steam pipes, that the valves should be considerably reduced in size, and that being provided with conical ajutages there would be but little consequent loss. Subsequently, S. Z. de Ferranti took out a patent for a valve in which this idea was embodied. He argued that the reduced pressure in the reduced passage-way, due to "venturi" effect, would be largely restored when the velocity became normal in the again enlarged pipes. Valves are now made according to the Ferranti patent, the novelty of which appears

to be the provision under the gate of the valve of a simple perforated extension gate, which, when the valve is open, exactly fills the throat of the valve and leaves a free, smooth passage-way for the steam. The great objection to the Ferranti valve is, however, the fact that it prevents the free flow of water along a pipe, the upward slope of the conical ajutage of the valve acting as a dam, and allowing water to accumulate along the bottom of a horizontal pipe to a depth of one-fourth of the pipe diameter. According to the original proposer of the reduced diameter valve, it is carrying ideal form too far in making the approach cones of the valve, right cones; they ought to be oblique cones with their lower sides parallel with the pipe and level with the lower sides of the pipes connected, so that there may be uninterrupted flow for water along the pipe, thus obviating all need for special drain cocks. Thus in the oblique cone valve the slope of the cones towards the throat is one-half of the pipe diameter at the top, and nil at the bottom; the valve throat itself having a diameter one-half that of the connected pipes. The theory of the valve is that if correct stream line passages are given, the pressure of the steam will be converted into velocity at the narrow way, and reconverted into pressure after passing the valve. The loss of pressure of steam flowing in a pipe is measured chiefly by friction, and, therefore, is a function of the length of the pipe. A short length of small diameter will only add that frictional loss which is proper to the velocity of the steam through the short length. Hence the small loss of efficiency, so long as the passage-way is well designed to be free from eddy corners.

Some engineers, however, refuse to believe that the steam will recover its pressure after passing even the best designed stream line throat. Perhaps it is that the reduction of the area of the valve passage-way to one-fourth that of the line of pipes in which the valve is placed, is too great a reduction for general practice.

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Writing on the influence of air in a condenser, Mr. D. B. Morrison points out the pernicious effect of air (which, of course, includes all non-condensable gases) in a surface condenser.

As he rightly says, if it were not for this air the vacuum in a condenser would coincide exactly with the temperature. Whenever the vacuum is less than that proper to the temperature, the discrepancy is due to air, and is explicable by reference to Dalton's law of mixed vapours. Where there is a vapourisable liquid, the space above that liquid must contain a certain weight of vapour of that liquid, no matter what other gas may be present at the same time. Then the pressure in a closed vessel of vapour of liquid and of air is the sum of what each would exert separately. In a condenser, therefore, all pressure above that proper to the liquid temperature is caused by the air that is present. As the condensable vapour is condensed on the cold tube surface, the air is, as it were, sieved out and remains in contact with the tube surface, and greatly reduces the condensing efficiency of the tube surface.

Since the steam disappears as it passes through the condenser, the mixture of vapour and air becomes gradually richer in air, and this increasing richness in air reduces the rate of heat transfer between the steam and the water. The capacity of the air pump obviously depends upon the point at which the pump draws out the air and steam. In order to prevent the necessity of too large an air pump, the air must be withdrawn before the temperature falls too low. The general effects of temperature and air leakage are discussed and the author draws attention to the action of his "Con-

traflo" condenser, which is so arranged with a series of diaphragm plates and chambers, that the water formed on each section of tube is caught and promptly delivered to the air pump without being showered upon tubes lower down and destroying their best absorption capacity. In the "Contraflo" condenser the steam flows across the tubes in a series of four, each succeeding chamber being smaller than the one before it, so as to maintain an approximately equal velocity of flow of the rapidly shrinking volume of mixed vapour. The preservation of the rate of flow over the tube surface tends to keep the air in forward movement, and to avoid that decrease of the surface efficiency which is caused when air is permitted to cling to the tube surface.

Various forms of condenser are shown which plainly illustrate the principles of construction and working that are aimed at. By passing the steam water directly to the pump at a high thermal value, an advantage is gained. The paper is well illustrated by tables and diagrams of great value.

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PROFESSOR ARNOLD, of Sheffield, is always interesting when he gets upon the subject of steel and its manufacture and testing, and a recent paper on factors of safety in Marine Engineering, read before the Institution of Naval Architects, forms no exception to the rule.

He says that, broadly speaking, engineers base their calculations of strength of steel upon the maximum stress capable of being endured by the material.

This is a value capable of accurate and rapid measurement upon the ordinary static testing machines of the workshop. It is, he says, also an accepted article of faith that the ultimate stress is really an indirect measure of the elastic limit in the ratio of two to one, or thereabouts. Professor Arnold admits this may usually be so, but nevertheless it is not so in the case of a few extremely important instances. Indeed it is quite hopelessly inadequate as a correct representation of facts.

Factors of safety appear, he says, to be calculated in practice by taking care not to subject a material to a working stress more than a quarter to a tenth of the maximum test endurance. In more scientific engineering, if N be the factor of safety, and X be the maximum test endurance, then $\frac{X}{N}$ = working load. And N is a product of several subfactors, a, b, c, d, namely, a = elasticity; b = Wöhlen phenomenon; c = rapidity of loading; d = unknown contingencies. Then N = a, b, c, d = factor of safety. This for nickel steel is as low as 2.25, while for a double-acting connecting rod it works out to 13.5 to 18. The factor (b), for example, is 1 for a steady load, as a bridge or boiler. (Presumably this refers to the dead load stress only.) In a single-acting connecting rod, in which stress varies from O to a maximum, b = 2, and in a double-acting rod, wherein stress varies from + max. to — max., b = 3.

Factor c is a rapidity factor varying from 1 for a steady load to 2 for a load suddenly applied, and 3 for sudden application with impact (How much impact?) ; d is an arbitrary factor for contingencies. The author now proceeds to show that steel may be over-annealed, and he quotes samples of steel heated to 950° C., and cooled spontaneously in air, and over-annealed steel maintained at 950° C. for 72 hours and cooled to milk-warm in 100 hours. In three steels, with 0.08, 0.21, 0.38 per cent. of carbon, the elastic unit was 12.19, 17.08, and 17.95, respectively; and there was no very great difference in test between the ultimate stress and the reduction of area between the three steels, but the over-annealed material had an elas-

tic limit of 8.82, 9.02 and 9.55, respectively. Now this elastic limit is really the yield point, and the true elastic limit is less than the yield point by 1¾ tons in normal structural steels, and 3½ tons in over-annealed steel. Thus the true elastic limit of the above steels is only 10.44, 15.35, 16.-20 for the normal, and 5.32, 5.52 and 6.05 for the over-annealed steel.

From another case the true elastic limit was only 3.9 tons per square inch, yet the tests showed good results, and the author suggests that, by over-annealing, mild steel may, like pure copper, have no practical elastic limit, or, is really plastic at any point above zero stress. He shows that in normal steels the assumed factor of safety of, say, 3, may really be 3.6 or more; but if the steel happens to be over-annealed, and the factor of safety was assumed as 6 to 1 on the maximum stress, instead of 3 to 1 on the elastic limit, it would only be something less than 1½. And such cases have actually come within the author's ken.

Generally, open-hearth steels contain 0.4 to 0.8 per cent. of manganese, and this much modifies the effect of over-annealing, and for this reason the author recommends 0.8 per cent. of manganese as a precaution against the risk. In the case of over-annealed shafts, the author gives an average tabulation of some 20 determinations of several cases. The true elastic limit is 8.5 tons; maximum stress, 28.5 tons; elongation on 2 inches, 30.5; and reduction of area, 52.5 tons. Presumably such shafts would be supposed to have an elastic limit of 15 tons, corresponding to 30 tons ultimate stress, yet the factor of safety intended, say to be 3.5 on the elastic limit, is really only the very inadequate one of 1.9. All the shafts fractured in use.

As a result of his investigations into over-annealed steel, Professor Arnold advises a new method of stress testing which is a modified form of Wöhler's method of alternating tests stress. He aims to bring Wöhler's method of repeated alternations into practical use by reducing the time necessary to make the tests. His argument is that instead of making the tests just within the elastic limit, they should be made just beyond it, and would thus quickly reflect the liability to fracture within the elastic limit under long-applied stresses. This method has been proved even to predict liability to fracture from causes quite apart from Wöhler's fatigue phenomenon, and proved potential brittleness which Wöhler's test failed to detect, and even pronounced to be absent. The author applies 650 alternations per minute by means of a slot in a reciprocating bar, through which the test piece projects. From the striking line of the bar to the plane of maximum stress at the face of the holding die is 3 inches, and the movement of the tested piece is ⅜ of an inch at the striking point. Though the test does not reproduce any known condition in engineering practice, it does, argues the author, predict liability to failure of material that would pass Wöhler's tests and fail in practice.

As a proof of this, some specially made bad steel—high in phosphorus—was tested. Three steels with phosphorus .41, .302 and .509 showing excellent static tests, showed a ratio of resistance to alternating stress of 1.0, 2.7 and 10.6 by Wöhler's method on a test of + 15 to — 15 tons. But by the author's method, the author knowing nothing of the material, the first showed a ratio of resistance of 100 and the third sample of 37, thus reversing the previous decision by nearly 30 times, the dangerous high phosphorous steel being found wanting.

# DUGALD CLERK, M. INST. C. E., F. C. S., ETC.

A BIOGRAPHICAL SKETCH.

THERE is probably no one name more familiar to designers of internal-combustion motors than that of Dugald Clerk, both as a writer and as a practical engineer in this important field.

Mr. Clerk was born at Glasgow in 1854, and after a private education he went to the West of Scotland Technical College, and subsequently to the Andersonian College and Young Chair of Technical Chemistry, Glasgow, and finally to the Yorkshire College of Science, Leeds. He was afterwards apprenticed at his father's works in Glasgow and in the drawing office of Messrs. H. O. Robinson & Co., engineers, Glasgow. His training thus covered both the theoretical and practical sides of engineering, and fitted him admirably for the nature of his subsequent work.

In 1876 the attention of Mr. Clerk was drawn to the gas engine, and, in the "Historical Review" in the Gas Power Number of this magazine, published in November last, there is an extended reference to his work in this field, and especially to the two-cycle gas engine which he produced in 1881. He joined Messrs. Thomson, Sterne & Co., of Glasgow, in 1877, and in that year began his experimental researches on the gas engine and the explosion of gaseous mixtures, when he took out his first gas-engine patent.

In 1878 Mr. Clerk designed the first gas engine ever operated with a power impulse every revolution and using compression before ignition, this being the first practical two-cycle gas engine.

This engine had two cylinders, one being a motor cylinder and the other a pump or displacer cylinder. The pump compressed the explosive mixture of gas and air into a reservoir, from which the motor cylinder was fed for every forward stroke. The ignition was effected by means of an incandescent platinum cage, and the heat of the successive explosions was sufficient to keep this cage hot without requiring any external source of heat.

Mr. Clerk's papers presented before scientific societies have been important and valuable. In 1882 he read a paper before the Institution of Civil Engineers on the "Theory of the Gas Engine," for which he received a Watt medal and a Telford premium. In this paper the theory explaining the influence of compression in the gas engine was enunciated for the first time. In the same year Dr. Otto expressed the theory of stratification, which caused a great deal of controversy, and it is generally believed that the late Mr. Justice Pearson's decision in favour of the Otto patent, in which was a claim for stratification, did much to retard the progress of gas-engine construction by bringing all practicable compression gas engines under the scope of the Otto patent of 1876.

In 1886 Mr. Clerk read a paper before the Institution of Civil Engineers upon the subject of the "Explosion of Gaseous Mixtures," and in 1896 he published a book on the "Gas Engine," which had a very large sale, and which was considered a standard authority on the subject.

In addition to the book mentioned above, Mr. Clerk has read many scientific papers and lectures before the leading learned bodies, including the Royal Society, the Institution of Civil Engineers, the Society of Chemical Industry, the Society of Arts, etc.

In 1902 he was awarded the medal of the Gas Institute, and in 1907 he received the Telford gold medal. He delivered the James Forrest lecture before the Institution of Civil Engineers in 1904, and in 1905-1906 he was president of the Junior Institution of Engineers. Among the important papers read by Mr. Clerk may be mentioned one entitled "Coal Gas for Motive Power and Heating," delivered before the Sheffield Society of Engineers and Metallurgists.

Besides his own consulting practice, Mr. Clerk is a director of the National Gas Engine Company, one of the most successful builders of gas engines in England.

Mr. Clerk is a member of the Royal Automobile Club; member of the Export and Technical Committee of that body, and was judge of the Automobile Club trials at the Richmond Show in 1899, in the 1,000-mile trials in 1900, and in various other trials.

Mr. Clerk has been elected president of the Engineering Section of the British Association for the Advancement of Science for the Dublin meeting for the present year, and is also joint secretary of the British Association committee for the determination of the temperature of gaseous explosions.

WILLIAM DANA EWART

INVENTOR OF THE DETACHABLE-LINK CHAIN BELT

SEE PAGE 287

# CASSIER'S MAGAZINE

VOL. XXXIV JULY, 1908 No. 3

## WORKS ENGINE HOUSES

By Arthur Titley

POWER HOUSES may be divided into two distinct classes: those coming under the general heading of central power plants, generating power for distribution, as in the case of electric-supply stations and similar establishments, this group including waterworks and electric tramway power houses, and those forming the power-generating plants of manuacturing and engineering establishments.

In Great Britain, with the exception of Lancashire and the other centres of the textile industry, the arrangement of the works power plant has rarely received the respect and attention which its importance in factory economics deserves.

Referring especially to the metal trades, it seems as if any hole or corner in the works has been thought good enough to house this important portion of the machinery, and even now there are many factories and mills in which the engines are left open to the accumulation of dirt and grease, to which the rest of the machinery is exposed.

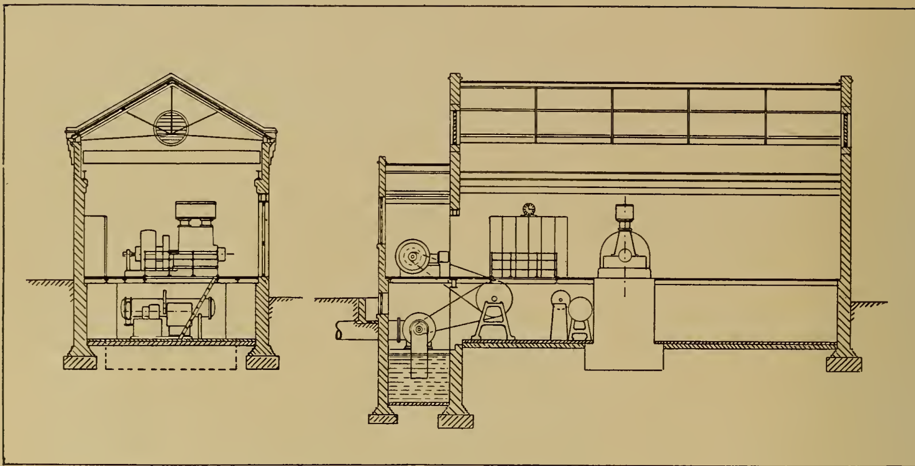
The moral effect of this is obvious, or ought to be, and is to be seen in the treatment the engine receives from its attendant, whose status is naturally parallel with that of his charge. In a well-equipped engine house of, say, a cotton mill, the engineman is one to whom respect is due as a master of his craft, and this is to be seen in the manner in which his engine is adjusted and kept clean, and is nursed through the troubles inherent to its peculiar constitution.

On the other hand, in such works as rolling mills, etc., one frequently sees engines in the hands of men who are quite incapable of appreciating a fine piece of machinery, and their necessary adjustments are made by "sledge-hammer" methods, as are those of the crudest piece of machinery on the ground.

The modern development of the electrical distribution of energy has done much to improve matters in this direction. In this case the situation of the power house is nearly independent of the location of the machines to be driven, while the attendant must have a knowledge of electricity in addition to that of engine-driving. Thus the question both of the housing and the running of electrical plants receives greater attention than such subjects previously did, and no one seeing the cleanly-kept modern power house can doubt that the change is one that pays.

The condition of things with electrical driving is ideal, from the point of view of the engine-house designer.



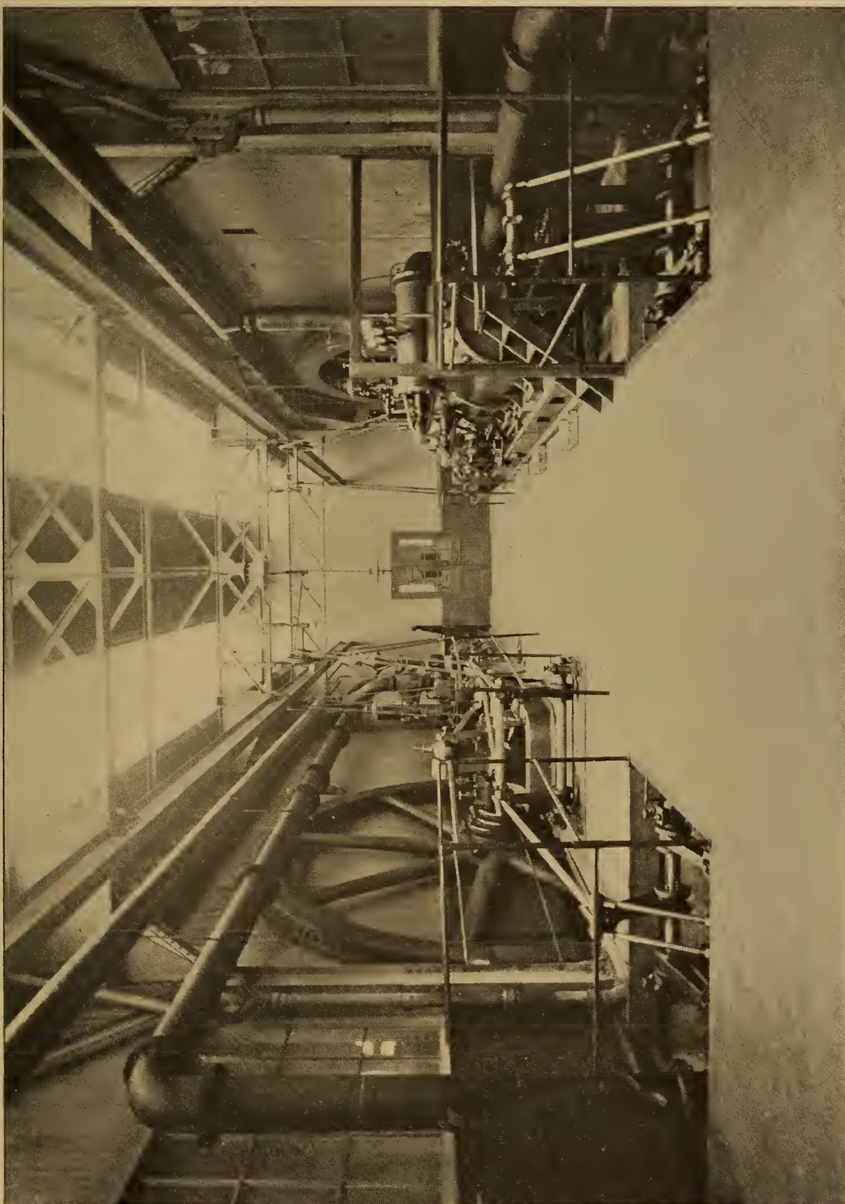
GENERAL ARRANGEMENT OF A WORKS POWER HOUSE

Reasonable proximity to the boilers and to the supply of cooling water for the condenser, if one is used, are the principal points he has to look to in fixing its position; next to this, a clear way for getting heavy parts in and out is to be preserved. A central position or nearness to those points to which the heaviest currents have to be conveyed, of course, means economy in the cable lay-out.

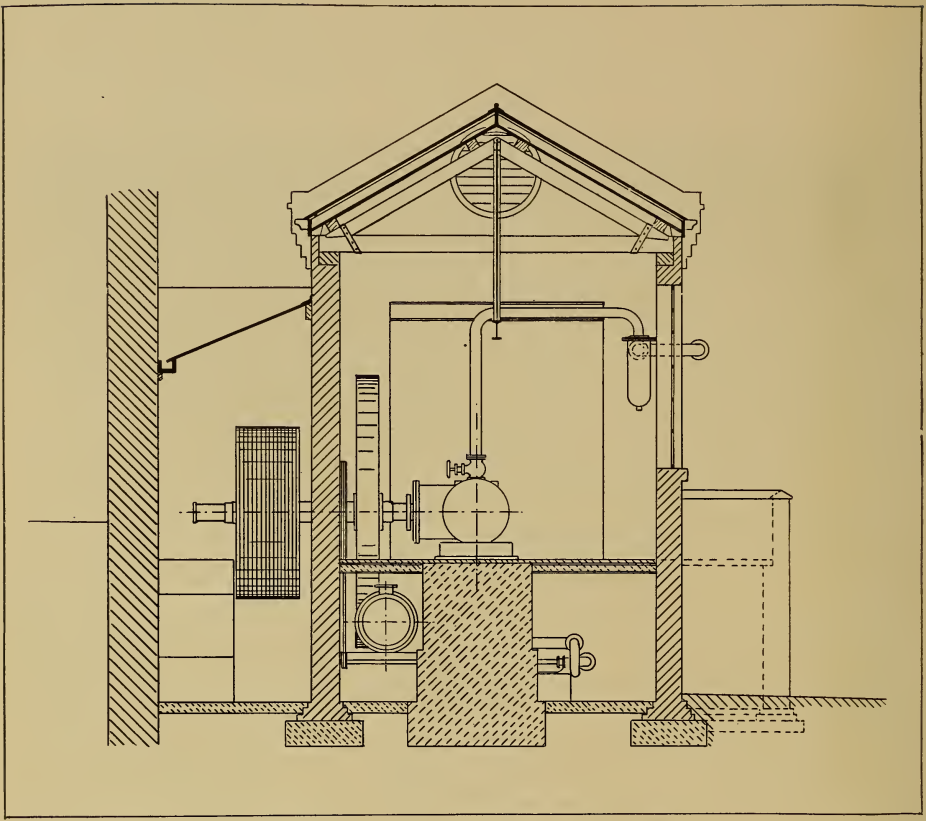
The case is far more complex when we come to mechanical driving. Given a suitable site for the power house, conditions laid down by the position of the second-motion shaft are apt to be very troublesome, as in the case of back driving by ropes illustrated. Here the best utilization of the ground available and the position of the canal settled the location of the engine house; but the position of the second-motion shaft being previously fixed, the interior was unavoidably cut into by the rope drive, while the height of the shaft necessitated a massive and costly foundation and fixing for it inside the building. Owing to these circumstances there is little passage-way across the house. In this particular instance an excellent feature is to be seen in the arrangement of levels as regards the cooling water, there being a head on the circulating pump intake; and also in the relation of the floor level to the lower ground level, which allows of a cart being backed up to the building, so that any part of the machinery can readily be loaded for removal or return.

The foundations of engine house and engine beds are, of course, of leading importance, and often cause much anxiety to the engineer responsible for their construction.

This work should always be liberally designed as regards mass of brickwork or concrete, and also as regards width of base; it should always be carried down to a solid foundation, if one is to be obtained at all. Where there is bad ground or running sand, a good thickness of concrete should be laid over the whole site, having strong steel reinforcement, such as old rails or I-beams, bedded in so as to make a strong platform to distribute the weight uniformly. If properly constructed, such a foundation will rarely give any trouble; whereas if the problem is not boldly tackled at the commencement, matters can never be properly rectified afterwards. Concrete should be considerably stronger than that generally used for building work, and close supervision of the quality of the materials and of the manner of mixing and putting in place should be observed. The very best cement should be used, and the sand should



A MODERN ROLLING-MILL ENGINE HOUSE



CROSS-SECTION OF A FLOUR-MILL ENGINE HOUSE

be the best the locality can produce. Hard, broken brick makes good concrete, as also does furnace slag, if clean and free from chemical impurities, which may injure the cement and ultimately disintegrate the work.

Brick laid in cement mortar makes very good foundation-work and much simplifies the setting out of hand holes and the building in of plates for holding down bolts; in fact, even when the body of the bed is of concrete the writer prefers to build outline walls to the plate level, and so facilitate this preliminary work.

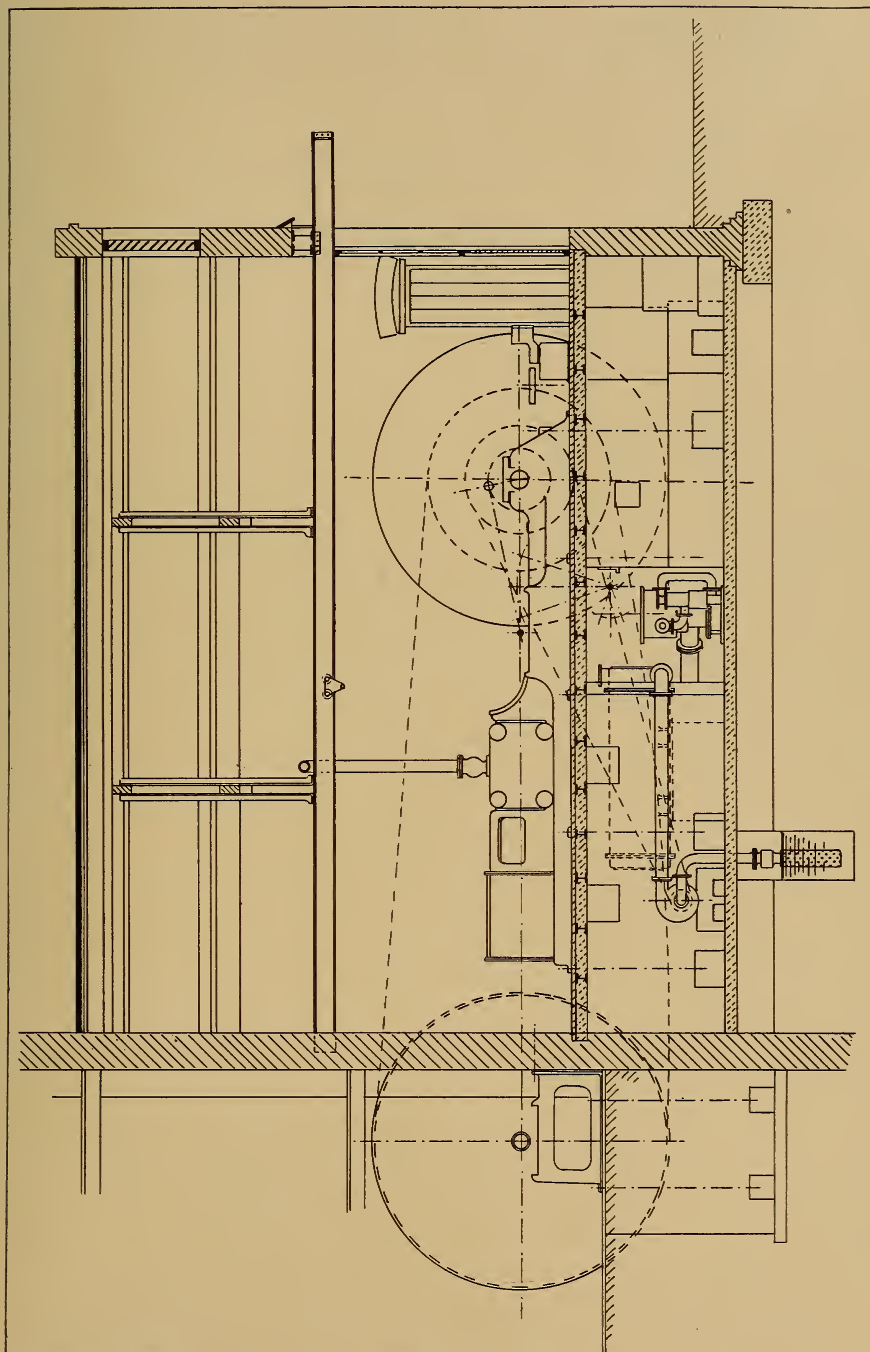
When the body of the bed is of concrete great stiffness is required in the timbering forming the mould in which it is formed, otherwise bulging and distortion of the sides of the bed and errors in the centres of the holding-down bolt-holes will result.

Trouble rarely arises from vibration in beds of horizontal engines. The speed is usually moderate, and the length of base is great in the direction of the greatest stresses; but with vertical and high-speed engines the case is different.

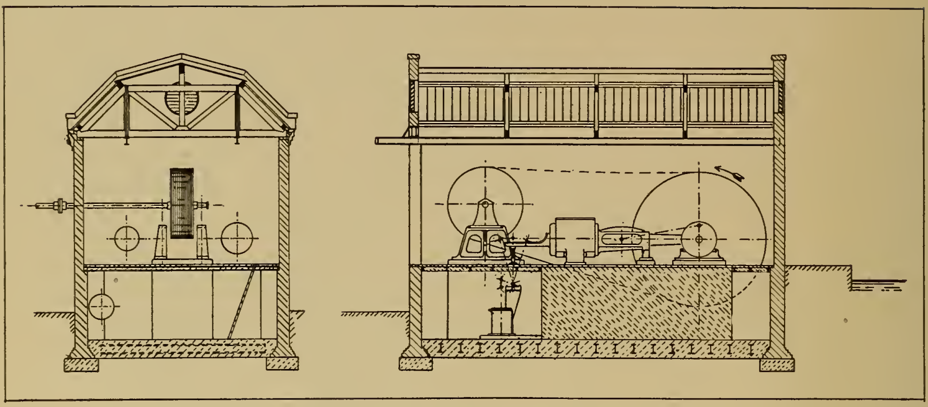
No matter how well balanced a reciprocating engine may be, if a good foundation is not obtained or insufficient spread of base is given to the bed, trouble will ensue, and money judiciously spent in this direction is always a good investment.

If pipe arrangements are well thought out and holes are left in the engine-house walls and through foundation blocks (as is often needed), a much more creditable job can be obtained than by the rather haphazard method by which this work is usually carried out.

Good lighting of engine houses is



A FLOUR-MILL ENGINE HOUSE



AN ENGINE HOUSE BUILT ON RUNNING SAND

important, and is preferable in the form of vertical glazing, as this is more easily cleaned and is not subject to the great objection of leakage from the rain and snow.

Ventilation is also important and most difficult; perhaps opening windows and louvres are best for the purpose, but fixed louvres are open to the objection that driving snow will find its way through them and rust all the bright work about an engine. If there is any electrical machinery in the building this objection is much more serious.

The best kind of floor to use depends very much upon the design of the engines for which the house is intended. If there is no condenser work and not much pipe work to go below the floor line, brick on edge or granolithic paving are good for plain jobs, while tiles make a good finish to more elaborate ones.

But when much work is below the floor it is a great advantage to be able to lift the latter, especially over the condensing machinery. A good, removable floor of this kind can be made with rolled steel beams and timber boarding, and can be covered with the special heavy linoleums procurable for this purpose.

Condenser basements present several difficulties. In the first place, works engine houses dimensions are usually compromises between the extremes of the desirable and the necessary; and a fairly roomy engine-house floor often gives a cramped basement, as a large portion of the room is taken by the engine foundations.

Lighting is another trouble, especially when the engine-house floor is on a level with the ground and there is no space available for area lights.

The designer is also fortunate if he can find any natural fall to a drain to take away water from cylinder drips and air and feed-pumps and hot-well overflow, as well as that arising from accidental flooding of the basement; this also applies to the draining of wheel pits.

Where room is available, the best basement arrangement has an opening in the floor, with hand-rails around and ladderway down. This gives light and allows the crane to be readily used to lift any parts of the condensing plant out during overhaul. It also permits the man in charge to keep a better lookout on the running of the plant, as it is the most accessible plan generally.

Basements should be left open all around the engine beds, so that holding-down bolts can be got at readily. Many a day's labour has been saved by this precaution, for a broken bolt or stripped thread is not such an unusual occurrence as the uninitiated might be led to expect. For this reason the bolts should always be fitted with cotters at the lower ends, and

should never on any account be grouted in. Plenty of keying power is obtained by the time the bed-plates have been bedded and bolts have been properly drawn up; and to grout all up solid is waste of material and labour, and is worse than unnecessary.

Rope and gearing races leading out of engine houses form spaces for the accumulation of dust and dirt, which, in the case of rope-driving, gets stirred up by the air currents set in motion by the machinery and is carried to all parts of the engine and deposited there. This arrangement often cannot be avoided, and, even when it can, it would be thought detrimental to the appearance of the engine.

In flour mills this question of dust is particularly important. In the horizontal tandem-engine arrangement illustrated the exigencies of the drive necessitated a rather small rope pulley upon the crankshaft, the needed fly-wheel effect being obtained by means of a separate fly-wheel, which was retained in the engine house, while the ropes ran in an enclosed alley alongside.

The fly-wheel thus keeps up the appearance of the engine and enables the barring engine to be in its usual position.

For dealing with weights during erection, and subsequently for repairs and overhaul, an overhead crane is the best arrangement of all; but this is somewhat of a luxury. For horizontal tandem and cross-compound engines the following system has been found quite satisfactory by the writer in several instances: The whole of the end of the engine house below a girder near the eaves level is framed together in wood and glass, and is removable in sections. Steel beams are placed over the cylinder centre-lines, and are suspended from the girder and from the roof principals (which should be made heavy for the purpose) by attachments of the upper flange, these beams extending outside the house and forming a runway for blocks fitted with a hand traverse motion which can deal with any but the few heaviest parts of the engine and deposit them on a cart when needed.

The advent of the switchboard into works engine houses has introduced requirements beyond those previously existing; but these are of a simple nature, and present no difficulties, as a rule. Dryness, a good space, back and front, and a clear basement run for feeder and generator leads are the leading desiderata.

No very reliable information can be given as to costs of works engine houses, as the conditions laid down by speed, type, and personal taste vary so much. It may, however, be interesting to note that the cost of several houses for cross-compound and tandem horizontal, slow-speed engines of substantial, but not elaborate, construction, and for powers of from 200 to 450 indicated horse-power, have been found by the writer to vary from £1.75 to £2 per indicated horse-power of rated full load.

In conclusion, it may be pointed out that modern works power houses are often isolated buildings, occupying a central position, in which they are much in evidence. It may be undesirable and unappropriate that such buildings should be architecturally elaborated, yet a good effect can be obtained if their lines are designed with due respect to constructional fitness and architectural rule, and this without materially adding to their cost over the haphazard and unsightly buildings one so often sees put up for this purpose.

The modern steam engine has arrived, by a process of most drastic evolution, at a comparative perfection of design which has a beauty of its own to the educated eye, and the house built to receive it should be designed and constructed in the same spirit.

# THE WORLD'S COPPER SUPPLIES IN 1907

By John B. C. Kershaw

In the April issue of this magazine Mr. H. M. Hobart discussed the relation of the copper production to the development of the electrical industries of the world, showing the desirability of reinforcing the use of copper by some other metal, such as aluminium. The present paper, by Mr. Kershaw, forms an admirable supplement to that of Mr. Hobart, giving not only the present state of the copper-producing industry in various parts of the world, but also a review of its growth and fluctuations in the past.—THE EDITOR.

THE variations in the price of copper during the year 1907 were more marked than at any earlier period in the history of the metal. Between January 1 and December 31 standard bar copper lost over 40 per cent. of its selling value, and from the highest recorded price of £110-6-0 per ton in March, 1907, fell to £62 at the close of the year. Since the copper consumption of the world is now at the rate of 700,000 tons per annum, a fall in value of 40 per cent. is of enormous significance to both producers and consumers, for on the output of 1907 it means a loss of over £28,000,000 to the mining and smelting companies and a corresponding gain to the consumers. In view of the widely extended use of copper in the engineering industries, and of the extreme price fluctuations which have occurred during the past year, the following study of the figures relating to the production of the metal by the various mining countries of the world during the last ten years will no doubt prove interesting to readers of CASSIER'S MAGAZINE. The figures are drawn from the statistical circular for 1907 published by Messrs. H. R. Merton & Co., of London. For the purpose of the article, they have been arranged both in tabular and diagrammatic form. The latter method serves to bring out more clearly some of the changes that are not so apparent in the mere lists of the figures.

*I.—Relationship Between the Total World Output of Copper and the Production of the U. S. A. Mines.*

The aggregate output of copper in 1907 was 716,435 tons, and of this enormous total the U. S. A. mines contributed 395,090 tons, or slightly over 55 per cent. Ten years ago, or in 1898, the aggregate output was 429,626 tons, and the proportion contributed by the U. S. A. mines was 234,271 tons, or 54 per cent. Table I. gives the figures for the intervening years, and Fig. I. shows the same figures in diagrammatic form.

TABLE I.—TOTAL WORLD'S OUTPUT OF COPPER AND PRODUCTIONS OF UNITED STATES MINES FOR PERIOD 1898–1907 IN TONS OF 2,240 POUNDS.

| Year. | Total. | U. S. Mines |
|---|---|---|
| 1898 | 429,626 | 234,271 |
| 1899 | 472,244 | 262,206 |
| 1900 | 479,514 | 263,502 |
| 1901 | 516,628 | 265,250 |
| 1902 | 541,295 | 292,870 |
| 1903 | 574,775 | 307,570 |
| 1904 | 644,000 | 365,050 |
| 1905 | 682,125 | 389,120 |
| 1906 | 714,100 | 409,650 |
| 1907 | 716,435 | 395,090 |

Although the world's output of copper has increased by 66 per cent. in the period under review, the production of the U. S. A. mines has more than kept pace with this increase, and in 1907 the percentage is slightly higher than it was ten years ago.

The falling off of 14,540 tons on the output of the mines of the United States during 1907, as compared with 1906, demands, however, further comment. The reduced output was chiefly

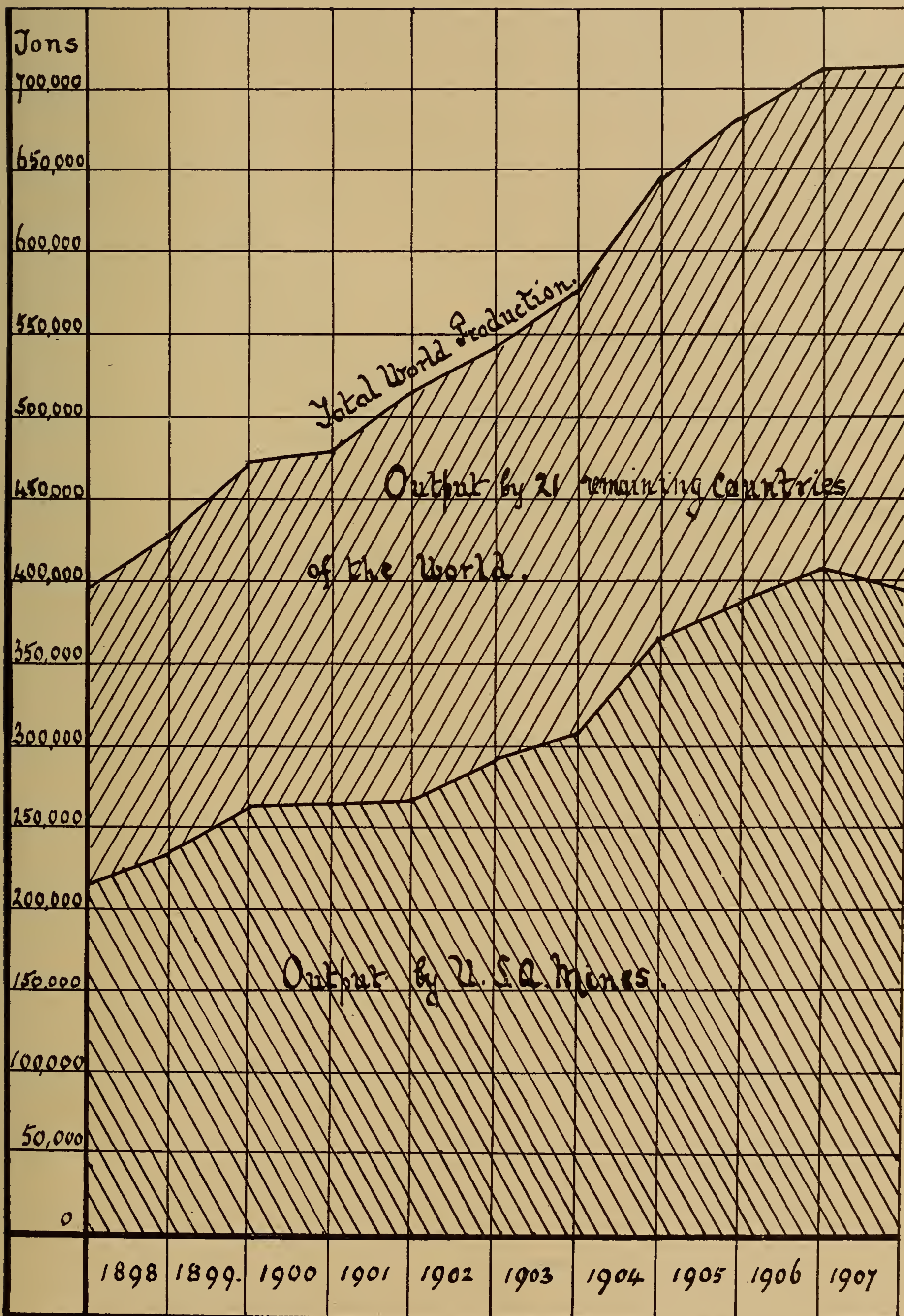



FIG. I.—CHART SHOWING TOTAL WORLD PRODUCTION OF COPPER FOR THE PAST TEN YEARS; COMPARING THE UNITED STATES MINES WITH THE REMAINING COUNTRIES

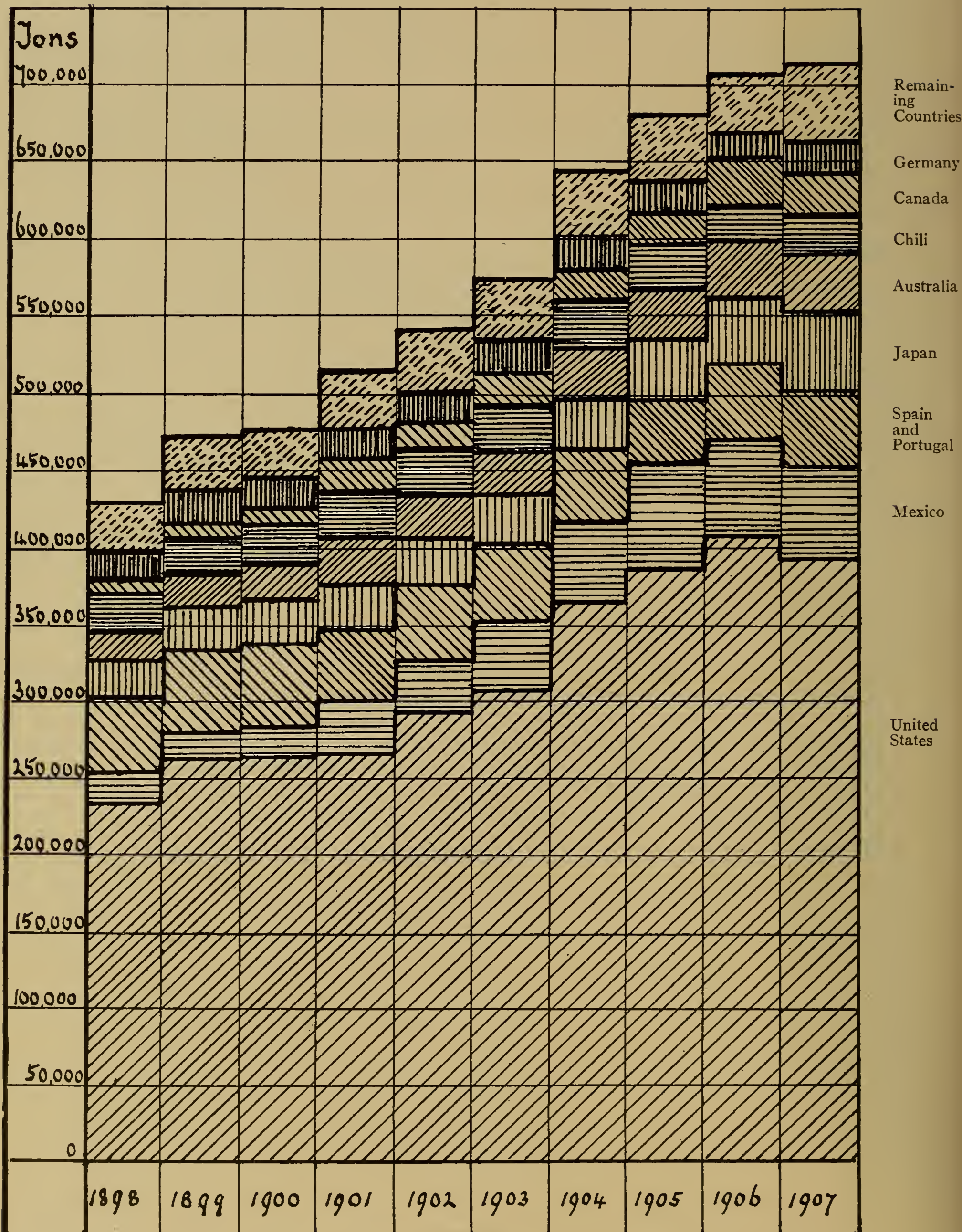



FIG. II.—CHART SHOWING TOTAL WORLD PRODUCTION OF COPPER FOR THE PERIOD 1898-1907, WITH PROPORTION CONTRIBUTED BY THE VARIOUS MINING COUNTRIES


FIG. III.—THE COPPER PRODUCTION OF SPAIN, PORTUGAL, JAPAN, MEXICO, AUSTRALASIA AND RUSSIA, DURING THE PAST TEN YEARS

due to the lessened production of the Montana mines, and the figures given in Table II., showing the output of the various States during the past five years, indicate that these mines have not been able to maintain their production at the high level reached in 1905. The deficiency of 32,000 tons on the output of Montana is, however, partly balanced by the gain of 20,000 tons in the output of the mines in the less well-known mining districts, and no doubt had the directors of the Amalgamated Copper Company desired it, the aggregate output of the U. S. A. mines in 1907 would have exceeded the 1906 total of 409,650 tons. The reduced

copper production of the United States in 1907 must be ascribed, then, to the great depreciation in the price of copper during the second half of that year, and not to exhaustion of the copper ore resources of the North American continent. The paramount place occupied by the United States among the copper-producing countries of the world is clearly shown in Fig. I., and the position revealed by this diagram is likely to continue for many years.

TABLE II.—Copper Production of the Various Mines of the United States During the Period 1903–1907.

| State. | 1903. | 1904. | 1905. | 1906. | 1907. |
|---|---|---|---|---|---|
| Calumet and Hecla | 34,150 | 35,865 | 37,950 | 40,000 | 40,000 |
| Other Lake mines | 50,655 | 57,140 | 59,820 | 60,030 | 58,660 |
| Montana | 109,375 | 133,180 | 142,490 | 133,860 | 101,635 |
| Arizona | 68,570 | 85,535 | 99,490 | 117,500 | 116,230 |
| Other States | 43,820 | 53,330 | 49,370 | 58,260 | 78,565 |

*II.—Changes in the Relative Position of the Eight Leading Copper-Producing Countries During the Period* 1898-1907.

The period 1898-1907 has been marked by the rise of Mexico from the seventh to the second place in the list of copper-producing countries, and by the marked diminution in the importance of the output of copper by the mines of Spain and Portugal and of Germany. Table III. gives the figures for the production of the United States, Mexico, Spain, Portugal, Japan, Australasia, Chili, Canada and Germany for the period referred to, while Fig. II. gives these same figures in diagrammatic form. These eight countries produce nearly 93 per cent. of the total world output of copper, and in 1906 the proportion rose to 93.8 per cent. The production of the remaining fourteen countries included in Messrs. Merton's return is, therefore, comparatively unimportant, and is signified by the dotted sections in Fig. II.

TABLE III.—Copper Production of the Eight Chief Producing Countries for the Period 1898–1907.

| Country. | 1898. | 1899. | 1900. | 1901. | 1902. | 1903. | 1904. | 1905. | 1906. | 1907. |
|---|---|---|---|---|---|---|---|---|---|---|
| United States | 234,271 | 262,206 | 263,502 | 265,250 | 292,870 | 307,570 | 365,050 | 389,120 | 409,650 | 395,090 |
| Mexico | 16,435 | 19,335 | 22,050 | 30,430 | 35,785 | 45,315 | 50,.45 | 64,430 | 60,625 | 56,565 |
| Spain and Portugal | 52,375 | 52,168 | 52,872 | 53,621 | 47,790 | 49,740 | 47,035 | 44,810 | 49,330 | 49,675 |
| Japan | 25,175 | 28,310 | 27,840 | 27,475 | 29,775 | 31,360 | 34,850 | 35,910 | 42,740 | 48,935 |
| Australasia | 18,000 | 20,750 | 23,020 | 30,875 | 28,640 | 29,000 | 34,160 | 33,940 | 36,250 | 41,250 |
| Chili | 24,850 | 28,000 | 25,700 | 30,780 | 28,930 | 30,930 | 30,110 | 29,165 | 25,745 | 26,685 |
| Canada | 8,040 | 6,730 | 8,500 | 18,800 | 17,485 | 19,320 | 19,185 | 20,535 | 25,460 | 25,615 |
| Germany | 20,085 | 23,460 | 20,410 | 21,720 | 21,605 | 21,205 | 21,045 | 22,160 | 20,340 | 20,490 |
| Totals of | 399,231 | 437,959 | 443,894 | 478,951 | 502,880 | 534,440 | 602,380 | 640,070 | 670.130 | 664,305 |
| Percentage of total world production | 92.9 | .... | 92.6 | .... | .... | 92.9 | .... | .... | 93.8 | 92.7 |

The countries that have become more important as copper-mining countries during the ten years are Mexico, Australasia and Canada, while Spain and Portugal, Japan, Chili and Germany have failed to maintain their position during this period. A more detailed examination of the figures for these countries (also of those for Russia and Peru) is shown in Diagrams III. and IV. The study of Fig. III. shows that Japan has made a notable increase in its copper production during the ten years, and that it will probably displace Spain and Portugal from the third place during the present year. The diminishing importance of Spain and Portugal and of Germany is clearly demonstrated in these two diagrams. The countries which are on the upgrade as regards copper production, from which an increased output may be expected during the next three years, are, therefore, Japan, Australasia, Russia, Canada and Peru. The position of Mexico is uncertain. The great increase in production which marked the period 1898-1906 was entirely due to the re-opening and working of old mines, and the falling off of 1907 may be due either to the final exhaustion of this source of copper or to a refusal of the American financiers to sink


FIG. IV.—THE COPPER PRODUCTION OF CHILI, GERMANY, CANADA AND PERU FOR THE PAST TEN YEARS

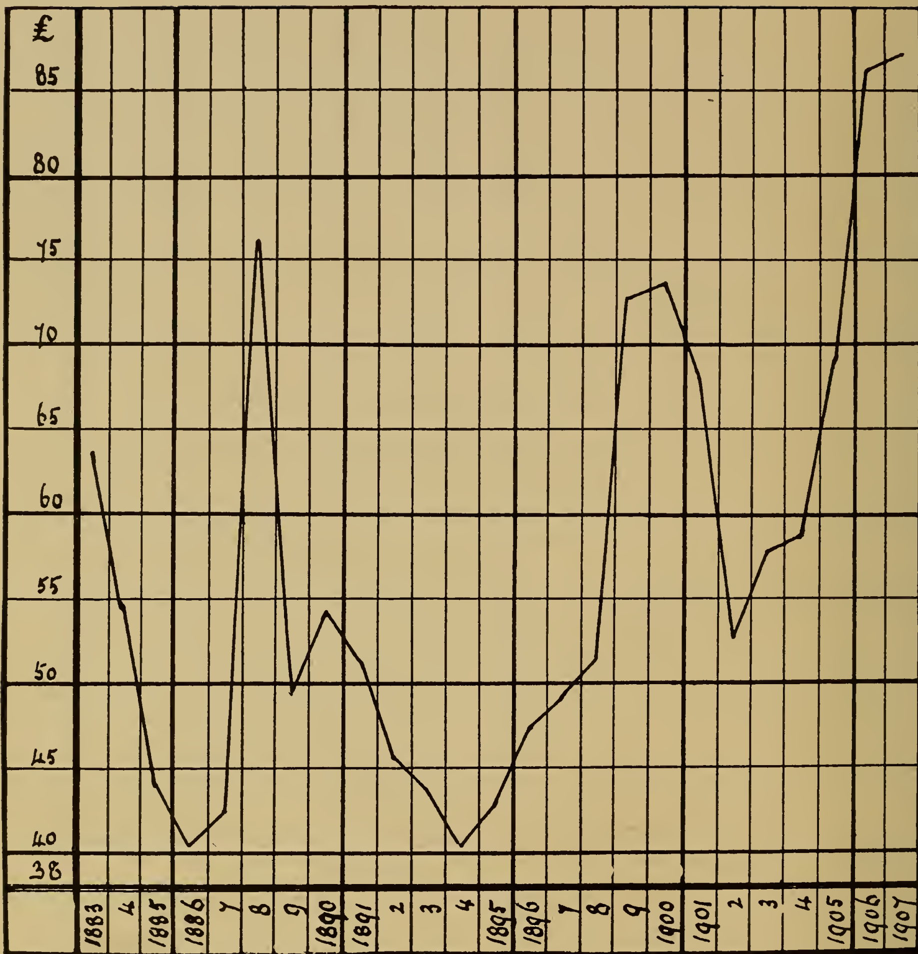



FIG. V.—THE PRICE OF COPPER DURING THE PAST TWENTY-FIVE YEARS. 1888, PARIS CORNER IN COPPER; 1899, FORMATION OF AMALGAMATED COPPER CO.

more capital at present in these properties. The decreased output of 1907 may, therefore, be only temporary in character, although the writer is inclined to think Mexico has passed its zenith as a copper-producing country.

TABLE IV.—THE AVERAGE PRICE OF BAR COPPER FOR THE PERIOD 1883–1907.

| Year. | Price. | Year. | Price. |
|---|---|---|---|
| 1883.......... | £63- 8-9 | 1895.......... | £42-17- 6 |
| 1884.......... | 54-15-6 | 1896.......... | 47- 4- 8 |
| 1885.......... | 44- 1-6 | 1897.......... | 49- 0-10 |
| 1886.......... | 40- 6-0 | 1898.......... | 51- 7-10 |
| 1887.......... | 42- 3-0 | 1899.......... | 72-16- 6 |
| 1888.......... | 76- 0-0 | 1900.......... | 73-10- 7 |
| 1889.......... | 49-10-6 | 1901.......... | 67-19- 3 |
| 1890.......... | 54- 1-0 | 1902.......... | 52-13- 5 |
| 1891.......... | 51- 3-0 | 1903.......... | 57-18- 8 |
| 1892.......... | 45- 9-6 | 1904.......... | 58-14- 8 |
| 1893.......... | 43- 6-9 | 1905.......... | 69- 2- 6 |
| 1894.......... | 40- 2-6 | 1906.......... | 86- 5- 2 |

Average price, £87-1-8; highest, £110-6-0; lowest, £62-0-0.

*III.—Variations in Price for the Past Twenty-five Years.*

The figures showing the average price of bar copper during each year of this period, 1882-1907, are given in Table IV., and, in diagrammatic form, in Fig. V. No connection can be traced between the production and price in the case of copper, and the three periods when copper has shown a marked inflation of value have been due chiefly to financial causes, and not to any marked falling off in the output.

In 1888 M. Secretan attempted to corner copper and failed, as witnessed by the striking depression in the curve in the year 1889. In 1899 the Amalgamated Copper Company was formed in America, and copper once more soared up in value to above £72 per ton, only to be followed, in 1902, 1903 and 1904, by a return to a more normal level. The unprecedented rise which culminated in February and March, 1907, with bar copper at £110 per ton, was due chiefly to the extremely active state of the engineering and allied industries in the preceding years, and to a general rush of consumers to cover their copper requirements at a period when there was some slackening in the rate of production. This latest period of high price is now over, and it is likely once again to be followed by a number of more normal years for those interested either as the producers or consumers in the red metal.

The words that were used in concluding the article on copper which the present writer contributed to Cassier's Magazine in 1906 may, however, be employed in bringing this later contribution to the study of copper statistics to a close:

"The position as regards the future is somewhat uncertain. Prophecy would be out of place in an article that is mainly a record of facts and figures. That the production of copper will increase for some years in sympathy with the demand, is evident. Will old Mother Earth, however, be able to continue for any considerable length of time supplying us with copper at the rate of 700,000 tons per year; and, if the supply fails, what metal will take its place?"

# RAILWAY BRIDGES OF MODERATE SPAN.—I.

By Conrad Gribble, A. M. I. C. E.

THERE is no doubt that a railway engine appeals more strongly to popular imagination as a mark of progress than does a railway bridge, and that a railway is judged and, perhaps, condemned by the traveling public more by the standard of its rolling stock than by the type of its girder bridges.

Many well-known bridges, of great span or of great height, are not visible from the carriage windows, and can be appreciated only from a distance.

The object of this article is to show, briefly, how the bridges built at the present time have been gradually evolved from the experimental arches, trusses and girders which served in the early days of the last century, and how the investigation of stresses in materials has brought about the evolution of the modern steel girder.

Perhaps it would be well here to offer an apology for the fact that nearly all the examples of bridges given in these pages are, or were, found on the lines forming the present North-Eastern Railway system. This system is composed of about forty small railways, designed by many engineers at different times, and, naturally, the bridges show great diversity of type. The first public locomotive railway now forms part of the system, and new branches and widenings have been undertaken and carried out all through its history, which, if it ever be published, will be found to be one of the most interesting pages of the railway history of this country. Though the bridges are of a widely varying character, they show a gradual progress from the days of little theoretical knowledge with great instinctive genius to the present time, when much more is known about the behaviour of different materials under stress and their suitability for different kinds of work.

Since this railway occupies an area in which a great number of rivers flow, the number of bridges is large. Examples of primitive design have abounded; but whereas stone and brick bridges will remain indefinitely, most of the early essays in girder making have been removed and replaced with more modern structures. The development of the building of metallic structures is marked by the change from the use of materials in a crude state to their employment in a scientifically transformed state in which they possess greatly increased strength and reliability. The latter quality is of greater importance than mere strength. If the power of resistance of a given material is closely known it can be used with reasonable certainty, whereas however great its strength may be under certain conditions, it is an undesirable agent if any unknown and incalculable weakness is possible.

The first materials for building purposes were stone and timber. These are produced by nature and shaped by man; but they undergo no alteration in their composition except that of seasoning, which is more a natural than an artificial process. It is not a matter for surprise, therefore, that masonry and timberwork are very much the same to-day as they were a century ago. They were not new materials then, and the last hundred years have not seen very

FIG. 1.—GAUNLESS BRIDGE, WEST AUCKLAND

great changes in the manner of their employment.

The most important material used in bridge building to-day is steel, an artificial chemical product which can be made in large quantities of known strength, weight and composition.

The newest material, or rather, combination of materials—reinforced concrete—unites three bodies, steel, cement and stone, in such a way that the valuable characteristics of each are used to the best advantage.

When we consider railway bridges we find that, for strength, immovability, permanence and grace, no improvement on a stone or brick arch has yet been made. Possibly reinforced concrete will be employed instead of masonry, and, in some cases, instead of girder work, to an increasing extent. Plain concrete in mass or in blocks has been used in the construction of some large viaducts with complete success. The engineer's ideal, however, is the masonry arch; but the cases in which it is possible to construct such a work are comparatively few. The reason why other types of bridge are built is mainly one of cost, direct or indirect.

Timber work is fairly cheap, but it is not found in sufficient quantities in England to overcome the objections due to its lack of permanence and rigidity and to its cost of maintenance. In America the supply of timber is large, and the national character has, perhaps, not a little to do with its adoption on a large scale as a building material. Speed and cheapness of construction have been the first objects of railway pioneers in America, whereas the motto in Great Britain has been, rather, permanence and stability.

A stone bridge of several openings each of moderate span is costly, on account of the number of piers and foundations; whereas when a stone bridge of large span is built the centering and temporary work add greatly to the total cost of the structure. When the desired span becomes very large it is impracticable to use masonry at all, and when the time for the work is short masonry again is put out of court.

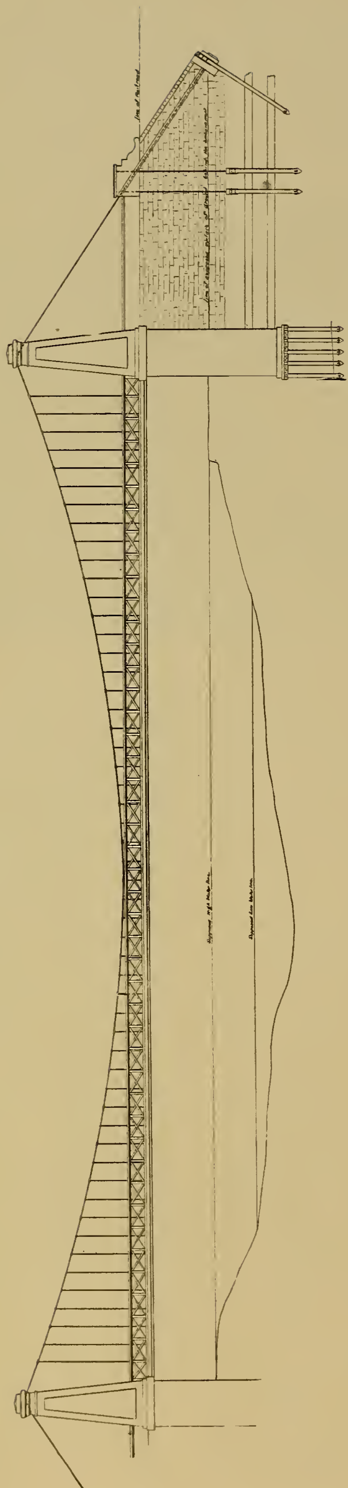


FIG. 2.—TEES SUSPENSION BRIDGE. CAPT. SAMUEL BROWN'S ORIGINAL DESIGN

These facts were brought forcibly before engineers when they began to build railway bridges, and they led to the use of iron on a large scale. There were iron bridges of considerable span in England before the days of railways; but they were very few in number, since there was no extraordinary need for bridge-building. These early bridges were of two types—the cast-iron arch and the wrought-iron suspension bridge. The girder as we know it now was a much later invention. In 1741 or thereabouts a suspension bridge was built across the river Tees above Middleton and near the High Force, which was used chiefly by miners and served as a foot-bridge only. This was of 70 feet span, and was the first known suspension bridge in England. The present bridge, the Wynch bridge, at this place is similar to the original bridge, which fell down in 1802, when one or two people lost their lives.

The first cast-iron arch was that over the Severn in Coalbrookdale near the town of Ironbridge, and was built in 1779 by Mr. Abraham Darby, owner of the adjacent iron-works. It consisted of a semi-circular arch of 100 feet span, weighing about 400 tons.

In 1796 Mr. Rowland Burdon built the fine arch over the river Wear between Sunderland and Monkwearmouth, which is composed of voussoirs of cast iron instead of long, segmental pieces. Robert Stephenson widened this bridge in 1858 and added wrought-iron spandrel bracing, and in this condition it remains, and probably will do so for a long time to come. Its span is 236 feet, with a rise of 34 feet.

From this date onwards several suspension bridges and arch bridges were made at different places for road traffic, the great expert in suspension bridge-building being Captain Samuel Brown, of the Royal Navy. He patented in 1818 the use of long links of wrought iron instead of short-link chains, and applied this system to the

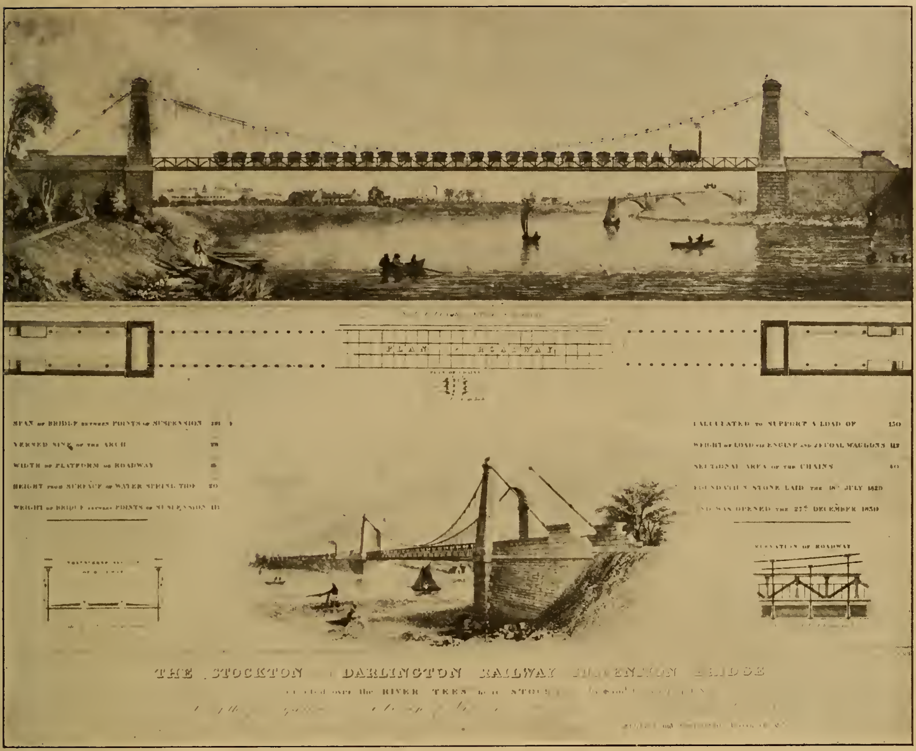


FIG. 5.—STOCKTON & DARLINGTON SUSPENSION BRIDGE

many suspension bridges he designed.

Before 1825, the dawn of railway enterprise, he had erected bridges at Montrose, Berwick and Galashiels, and had also built the celebrated chain pier at Brighton, which survived the rough seas and high winds of the English Channel until, in December, 1896, it succumbed to a great gale.

These bridges were not entirely satisfactory, and there was a disastrous accident at Montrose bridge when, in 1830, it partially collapsed under a crowd of people eager to obtain a good view of a boat race, and a great loss of life is recorded. Captain Brown was still more unsuccessful when he turned his attention to railway bridges, though his one work of this kind was not responsible for any serious accident or loss of life.

The first iron railway bridge, however, belonged to neither the suspension-bridge type nor to the arch type. It is an isolated case and difficult to classify, being much nearer our idea of a girder than anything else erected at this time. This bridge (Fig. 1) was built in 1823 over the river Gaunless near West Auckland, to carry the Stockton & Darlington Railway, and it consisted of four spans, each of 12 feet 6 inches, carrying a single line. For a long time the bridge was disused, as this portion of the line was abandoned in 1856, and when, in 1901, mineral traffic was resumed, the old bridge was removed and replaced by a modern bridge in a single span. Though its actual life was about seventy-eight years, it was not in active service for the whole time.

The whole bridge has been erected in the Old Coach Shops, North Road, Darlington, and it forms an interesting link with the past. The trusses were made by embedding the wrought-iron booms in the sand mould and

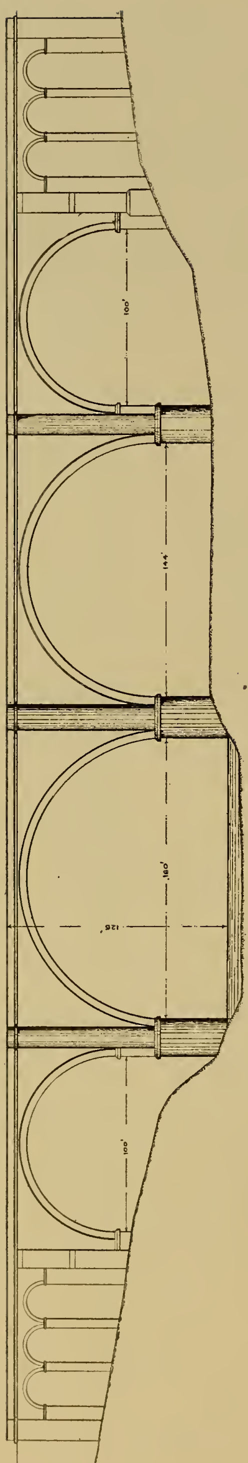


FIG. 4.—VICTORIA BRIDGE OVER RIVER WEAR. STONE ARCHES. T. E. HARRISON, ENGINEER, J. WALKER, CONS. ENGINEER, 1836–8

casting the vertical struts around them. The workmanship was excellent, and the joints were so perfectly fitted that great trouble was experienced in taking the trusses out of the columns. It is generally supposed to have been designed by George Stephenson.

To return to Captain Brown's suspension bridges. The sole example of a railway bridge of this type in the North-Eastern district was built for the Stockton & Darlington Railway in 1830. This bridge (Fig. 2) carried the extension to Middlesbrough, then nothing but a village, over the Tees from Durham into Yorkshire. It was a notable structure, and also a notorious failure. The traffic it was to carry consisted chiefly of minerals from the Durham coalfield. The first design, illustrated above, was not considered strong enough, and more chains were employed than are shown on the original contract drawing. All the iron work was tested at Millwall by Professor Barlow, and the subsequent failure does not appear to have been due to the quality of the material.

The bridge was opened in 1830 by being subjected to a prolonged series of tests by trains of coal trucks hauled by a special engine, new for the purpose. It was found that the deflection under the load was far too great for safety unless the trucks were taken across at distances apart of several yards, a long chain with couplings attached being used for the purpose. The faults of the design lay principally in the weakness of the timber stiffening truss and in the inclination of the back stays, the latter causing an overturning movement on the piers. The anchorage of these stays was also faulty, and though repairs were constantly carried out, matters grew worse and worse. Whereas the bridge was intended for a distributed load of 150 tons, it was found to be unsafe with more than 66 tons, the platform deflecting 7½ inches, and the masonry towers showing signs of movement. For some

time traffic was conducted over the bridge with great inconvenience and some risk until the permanent deflection of the platform became so excessive, owing to the loosening of the anchorage, that piles had to be driven in the river to support the bridge, and in 1841 the chains remained only to show that the bridge had been a suspension bridge. The original contract drawings for this bridge, signed by Samuel Brown, still remain, and can be compared with prints of a drawing of the bridge as actually built (Fig. 3) made by Mr. John Dixon, of the Stockton & Darlington Railway (Fig. 2).

In contrast with this unsuccessful bridge, the Victoria bridge over the Wear at Washington stands out sharply (Fig. 4). This was built in 1836-8, and is remarkable for the great size of the stone arches of which it is composed. The greatest arch is 160 feet in span and 72 feet in height from the springing, and is built partly of granite. Mr. T. E. Harrison, in consultation with Mr. James Walker, was responsible for the design and execution of the work. The height at which the railway was carried above the river enabled these great arches to be built, and they are exceeded in Britain only by the semi-circular arch of 180 feet span over the Water of Ayr at Ballochmile, on the Glasgow & South-Western Railway, and by the Grosvenor bridge, of 200 feet span, over the river Dee at Chester.

### TIMBER VIADUCTS

Some very different bridges were shortly after this erected on the Newcastle & North Shields Railway. Though masonry arches, such as those just described, were unsurpassed for strength and appearance, they took a long time to build, and they cost a good deal of money. Messrs. John & Benjamin Green, of Newcastle, architects, considered that timber could be usefully employed in the form of laminated arches. Two large viaducts (Fig. 5) over the Ouseburn and Willington Gut were built in this manner, and opened in about 1839. The piers were of masonry, handsomely treated, as befitted the architectural attainments of their designers, and the superstructure was of timber planks curved and fastened together to form segmental arch ribs. On these were the decking and permanent way. These viaducts, which were of a considerable number of spans, remained in their original condition until 1868, when Mr. T. E.

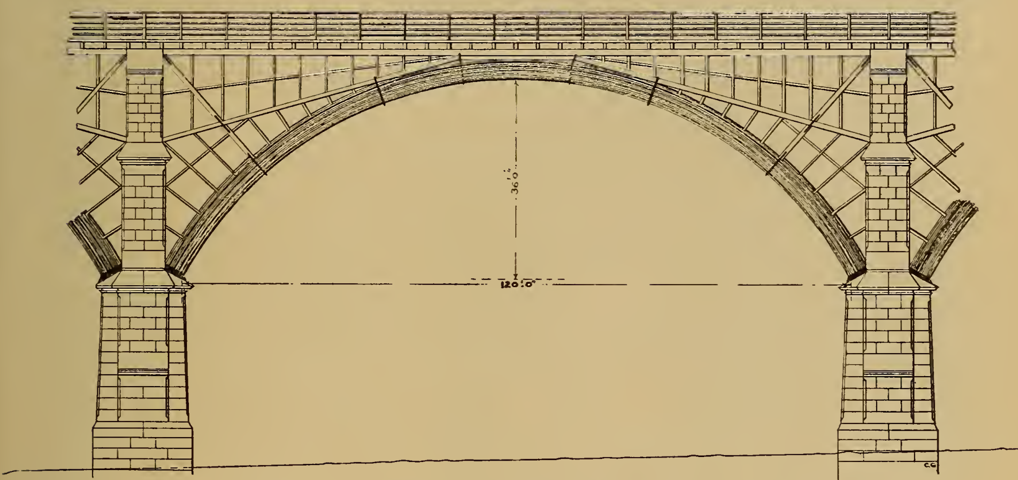


FIG. 5.—LAMINATED TIMBER ARCHES OVER WILLINGTON DEAN AND OUSEBURN DEAN, 1838. JOHN & BENJAMIN GREEN, ARCHITECTS. REPLACED 1896

Harrison, then engineer of the North-Eastern Railway, removed the timber work after constructing iron arches underneath. The piers were perfectly adapted to receive the new ironwork, and so the original design seems sound, in that while the rolling loads were light, the cheaper bridge sufficed, and when, after about thirty years, the bridge was hardly adequate for the increasing loads, every facility for renewal with a stronger and more lasting material was at hand.

To return, not for the last time, to the river Tees at Thornaby, it was soon evident to the Stockton & Darlington directors that a bridge must be built to replace the erstwhile suspension bridge, and, after some years of delay and inquiry, it was decided to accept designs submitted at their request by Robert Stephenson for a new bridge alongside. This was to carry a double line in five spans, consisting of trussed cast-iron girders upon masonry piers, the whole resting upon pile foundations. The engineer of the railway, John Harris, did not approve of this design, preferring stone arches to what were then considered new-fangled girders. Stephenson, however, assured the directors that his bridge would be sufficient and less costly than one wholly in stone.

By this time, 1842, cast-iron girders were becoming common, and elaborate experiments on the transverse strength of the material were made by Hodgkinson. The weakness of cast iron to resist tension was discovered, and the difficulty of making girders of large span in one piece proved a serious obstacle.

The system of trussing built-up girders of cast iron with wrought-iron straps, to relieve the tension in the lower flange, was first employed by Mr. G. P. Bidder in a bridge over the river Lea at Tottenham, and Sir Wm. Fairbairn, in a paper before the Institution of Civil Engineers, advocated the use of such girders for building construction; but his suggestions were criticized considerably.

Stephenson's girders for the Tees bridge (Fig. 6) were 89 feet long, in three pieces connected with bolts and cotters, and trussed with wrought-iron straps. The ironwork was made at the Sheldon Works, between Darlington and Auckland, and the excellence of material and workmanship in these girders was unsurpassed. With the idea of adding strength to the bridge, the whole of the five spans were connected together into one continuous piece by bolts and straps over the piers, so that there were continuous girders of a length of about 330 feet. The bridge was opened for traffic in May, 1844, the work of construction having taken about two years.

Though no fault could be found with the bridge itself, great uneasiness was caused just three years later by the collapse of an almost exactly similar bridge over the river Dee at Chester, where the girders appear to have been identical with those at Thornaby, except for length. They were about 108 feet long and in three pieces, and the bridge was of several spans. After the trains had been running over it for a few weeks one girder collapsed, throwing the train in the river, and loss of life ensued. The fault was in the workmanship, but the system of trussed cast-iron girders was somewhat discredited.

Mr. Wm. Cudworth, then assistant engineer to Mr. John Dixon, of the Stockton & Darlington Railway, and father of Mr. W. J. Cudworth, to whom the author is indebted for the following story, was, shortly after the Dee accident, at the Tees bridge, in order to devise some means of strengthening the girders. Another and an older man was also there, seated on the river bank, paying great attention to the bridge. He proved to be the famous George Stephenson, father of the designer of the bridge, and he suggested that timber struts should be put under the girders in the manner shown in the illustration (Fig. 6), which would carry the load

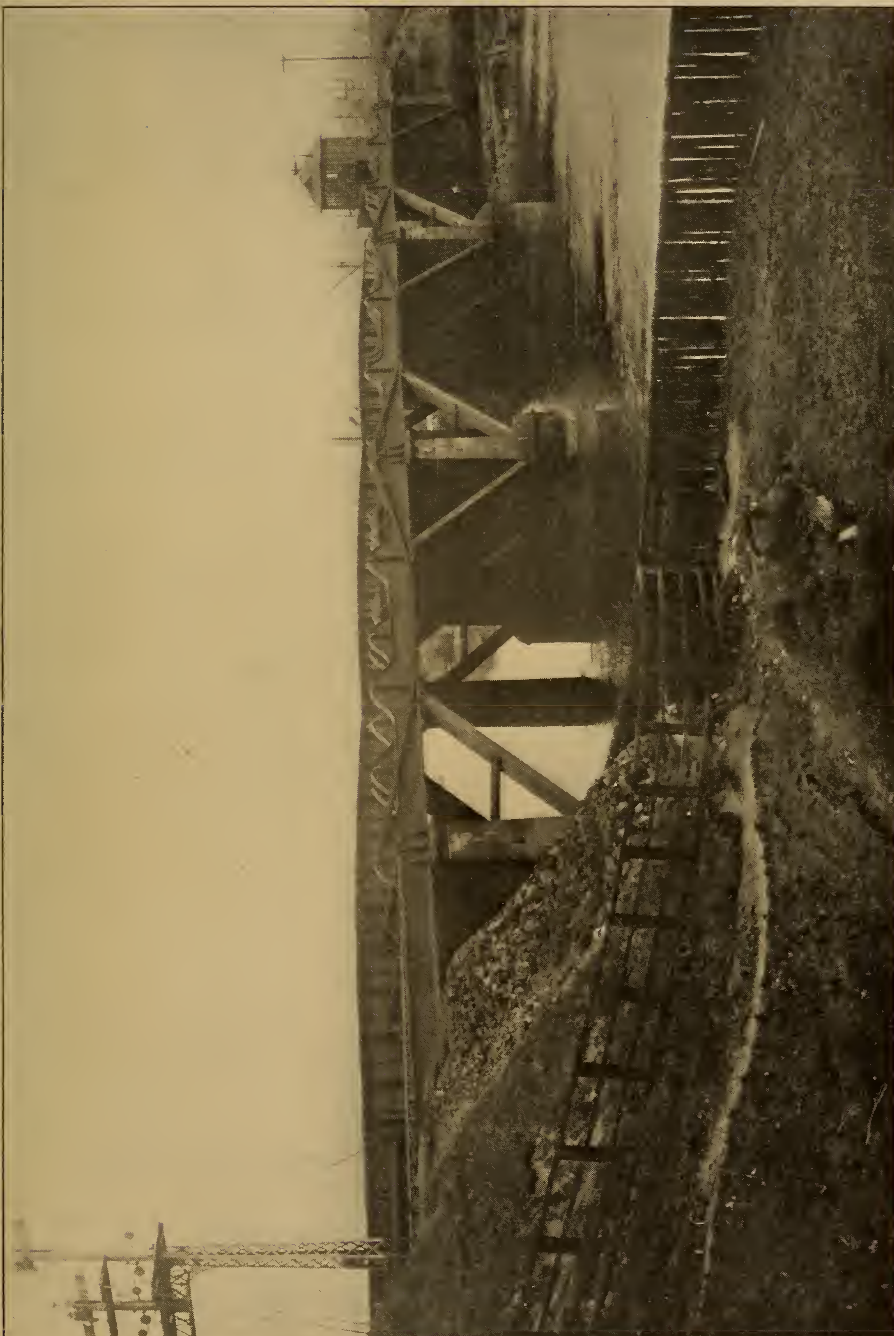


FIG. 6.—ROBERT STEPHENSON'S BRIDGE OVER RIVER TEES AT THORNABY

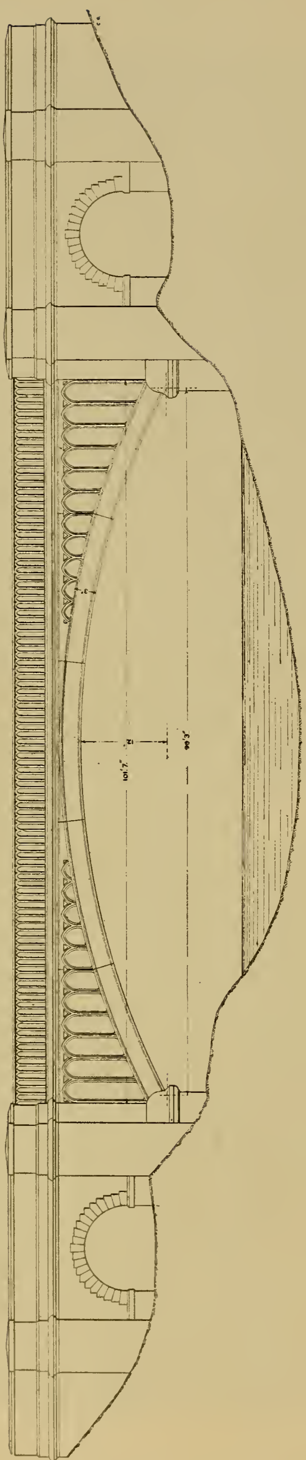


FIG. 7.—CAST-IRON ARCH OVER RIVER SWALE, NEAR THIRSK, 1847. ENGINEER, THOMAS GRAINGER. SIX ARCH RIBS. DOUBLE LINE RAILWAY, 99 FT. 3 IN. CLEAR SPAN

down to the abutments and relieve the girders of a great proportion of stress. This was done in 1849, and the girders remained in that condition until they were removed in 1906.

For the greater part of their life they were not subjected to anything like the stresses for which they were designed, owing to the assistance of the timber struts, and this was in spite of the fact that the moving loads increased rapidly as years went by; so Stephenson's contention that the bridge would be sufficient was fulfilled. Whether the girders would have sufficed without the strutting is, however, doubtful, and it is quite certain that Stephenson had not in his mind's eye any locomotive like those in use to-day on this section of the railway. A 25 or 30-ton coal and ironstone wagon, giving an axle load of 20 tons, would certainly have been far out of the reckoning of bridge designers in 1840.

The continuity of the girders already referred to, taken with some inferior masonry work in the end abutments, accounts for a good deal of damage caused to these abutments by the expansion and contraction of the 330 feet of ironwork. No allowance at all was made for this, and the girders were all securely bolted down to the piers, the holding-down bolts at the extreme ends being carried up from the very bottom of the pier—obviously to prevent the short-end girders from tilting up. Some of the joints over the piers failed, owing to slight settlements of the piers, throwing great local stresses on the girders. With these exceptions, the whole of the work was in excellent condition when, in 1906, Mr. W. S. Cudworth decided to renew the superstructure with steel work, the loads becoming rather severe for a cast-iron bridge sixty-two years old. Probably John Harris would have built a stone bridge which would never have required any renewal at all; and as such a bridge was quite possible at the site, it might have been

cheaper in the end, although more costly at first.

At the time when this bridge over the Tees was built wrought iron, except in the form of suspension bridges, or as a means of strengthening cast-iron girders, was not used in bridge-building on a large scale. Cast-iron arches had, of course, been put up years before, and had proved very satisfactory. In 1847 and about that time some fine arches were built, and that illustrated here carried the Leeds & Thirsk Railway over the river Swale near Topcliffe, Thirsk (Fig. 7). It consisted of six parallel ribs of 100 feet span, and accommodated a double line. The ribs were braced together with cast-iron frames bolted between them, and the railway was carried above the crown of the arch and on vertical spandrels. The rather pleasing parapets above the outside ribs were removed about twenty years ago, when the timber decking was renewed and the load on the arch reduced by the removal of a great quantity of accumulated ballast.

At present the bridge is in good condition, and will probably continue so for years, and entail small expense in maintenance. The commendable feature in cast-iron bridges, and especially in those of this type, where the whole of the work is exposed to the air, is the small degree to which they are subject to corrosion and loss of section. The arches are as strong to-day as ever they were, whereas a wrought-iron or steel bridge will, except with the most careful maintenance under the best conditions, certainly lose weight in sixty years.

On account of the enormous weight of cast-iron girders of great span their use was limited, though Sir Wm. Fairbairn mentions girders 76 feet in length in one piece which were made in England and shipped to Holland for the Haarlem Railway. These must have been the largest castings of this kind ever made, and what their weight was and how they were conveyed to the site and erected are matters for conjecture.

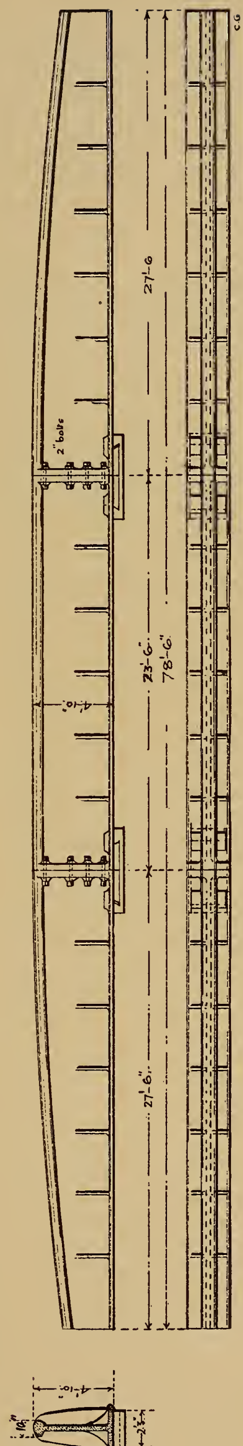



FIG. 8.—BRIDGE OVER RIVER DERWENT, NEAR SELBY. ERECTED 1848. ENGINEER, J. C. BIRKINSHAW. CAST-IRON GIRDERS 78 FT. 6 IN. LONG, 4 FT. 10 IN. DEEP AT CENTRE, WEIGHT 35 TONS. REMOVED 1881

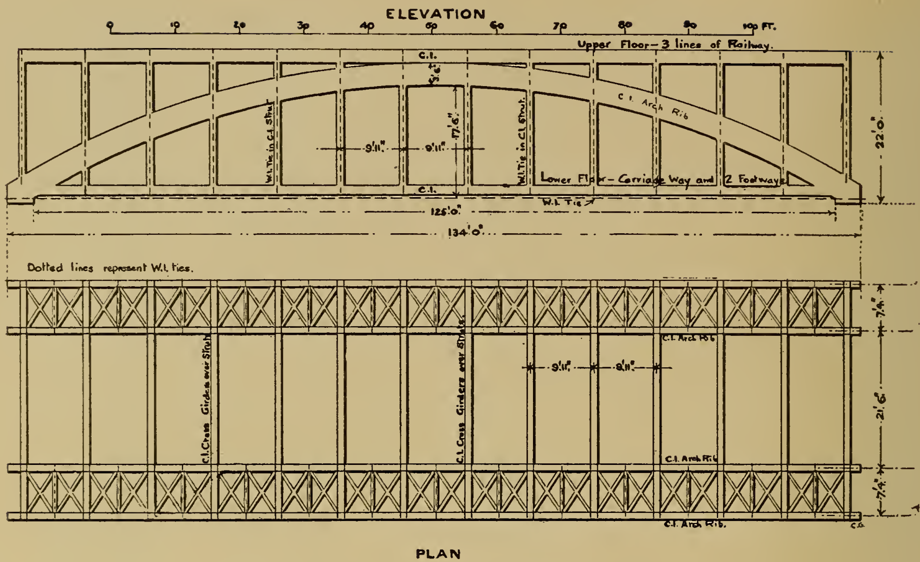



FIG. 9.—GIRDER OF HIGH-LEVEL BRIDGE, NEWCASTLE-ON-TYNE. ERECTED 1849. DESIGNED BY ROBERT STEPHENSON. T. E. HARRISON, ENGINEER

Some girders taken out of the bridge over the river Derwent at Bubwith, near Selby, in 1881, were made in three pieces, bolted and cottered together without any trussing bars (Fig. 8). These were made in 1848 for a branch of the York North Midland Railway, and were 78 feet 6 inches long, weighing 35 tons each. They are the largest untrussed cast-iron girders known to the author, and their great weight shows how uneconomical such girders are. One weakness of many cast-iron girders, whether trussed or not, was in their shallowness and narrowness. It was difficult to cast deep and wide girders and to ensure sound castings, and the efficiency of the wrought-iron straps would have been far greater if they had been applied at a much steeper angle and to much deeper girders.

The last example of cast-iron construction described here is really the finest of all, and one likely to be a monument to the genius of its designer for years to come.

Every traveler by the East Coast route to the north knows by name (though many have seen little of it) the High Level bridge at Newcastle. Now that the King Edward bridge, a little higher up the river, is regularly used by the through trains, many more people will have a glimpse of the older bridge, when the state of the atmosphere allows. It is impossible, of course, to take in the construction of either bridge when one is actually crossing it; but if one goes by the roadway, which is carried beneath the railway in the old bridge, one can examine it at leisure.

The Great North of England Railway was opened in 1841, and passengers from London traveled via Rugby, Derby, Normanton, York and Darlington as far as Gateshead. To proceed to Newcastle and Carlisle, they had to cross by road or ferry over the Tyne, and it became an urgent matter to prevent this break of journey and provide a bridge over the river at the level of the railway. The York, Newcastle & Berwick Railway, of which Mr. T. E. Harrison was engineer, and Robert Stephenson consulting engineer, accomplished this in 1849. Many designs had been submitted for bridges, consisting of timber arches, stone arches and all kinds of arches.

Robert Stephenson employed cast-iron arches tied by wrought-iron rods, so that the absence of an abutment to take the thrust of the arches was thus counteracted. Three lines of railway were carried above the tops of the arches on vertical cast-iron struts, with cross girders of trough section connecting the latter transversely. The engineers were then criticized for going to the expense of providing as many as three lines of railway; but the complaints which have been made recently have been on account of their not providing four tracks, and the extra expense would have been more than justified by the additional convenience. As an after-thought, a public carriage-way was constructed at the level of the springings, being suspended from the arch ribs by vertical ties. There are also two footways at this level between each pair of ribs at the sides.

The whole construction is on a great scale, and appears to be nearly as permanent as a stone arch would be. It has been in existence now for close upon sixty years, and no idea of renewing it is entertained.

It is not very easy to distinguish all the details of the design, as some of the essential features are concealed in the cast-iron members. The horizontal wrought-iron ties taking the thrust of the arches are below the level of the footways, and the vertical rods suspending the lower platform are encased in the vertical cast-iron members. The four arch ribs are grouped in pairs, giving a wide carrage-way, and two narrower footways (Fig 9). In 1894 Mr. C. A. Harrison strengthened the cross girders by placing additional wrought-iron girders beneath them, and in an ingenious manner relieving the old cross girders of load.

After half a century had elapsed the construction of cast-iron girders of more than very short span began to be discontinued.

In 1891, when a cast-iron girder mysteriously failed on the London, Brighton & South Coast Railway, it was considered that it was time to remove all such girders, and the Board of Trade reported adversely to their use. There are, accordingly, but few remaining now, and these are of small span and have a large margin of strength. There are many over-bridges carrying roads which are made on this plan; but these, again, are of small span. It may be well, before passing on to examples of wrought-iron bridges, to dwell a little longer on the characteristics of the older material.

The most important parts of an engineering structure, such as a girder bridge, are the joints. When a girder has to be made in a number of pieces its strength is the strength of its joints, and the greatest difficulty that engineers had to surmount in designing cast-iron girders of long span was to securely fasten the several pieces together.

From the nature of the metal and from the method of its manufacture nothing similar to a double-rivetted lap or butt joint, such as is used for joining iron plates, could be used, and no joint is so efficient. The only means was to cast flanges on the several portions of the girder, and to bolt and cotter them together; but however carefully the joints were machined, and however tightly the bolts were secured, the result was a hybrid construction, the actual strength of which was extremely difficult to calculate.

Further, a great margin of safety had to be used to allow for possible voids in the thicker parts of the castings and for internal stresses set up in cooling, so that the girders were of great weight. Also, it is not possible to graduate the strength of a girder satisfactorily throughout its length, as there is a limit to the amount of which different parts of a casting may differ in size and thickness, on account of cooling stresses developed in castings of varying dimensions.

To show how unsuitable cast iron

is for responsible engineering work, it may be mentioned that even to-day it is difficult to obtain really reliable data as to its strength in the form of a girder. Hundreds of experiments have been conducted in a highly scientific manner on small specimens of cast iron, but the results of these differ considerably, and when applied to large sections of the material do not give a fair indication of their strength. There is greater discrepancy between the strength of large girders of cast iron, as calculated from the strength of small pieces broken in the test machine and their actual strength, than there is between similar experiments made with mild steel. The great advantage, however, of cast iron beyond that of cheapness is its resistance to corrosion by atmosphere or water. There are many old girders in use to-day which are as strong as the day they were cast, the loss of section by oxidization being practically *nil.* It is rather a curious fact that the more scientifically iron is prepared and the greater its tensile strength becomes, the more liable it is to corrosion. Wrought iron is stronger in tension than cast iron, and it rusts more quickly. Steel is stronger in all respects than wrought iron, and it is still more rapidly deteriorated by the atmosphere. The aim of the engineer designing steel work should be to protect it from the effects of moisture and air, either by encasing it in a permanent weatherproof covering or by rendering it capable of periodical cleaning and painting. The claims advanced for reinforced concrete are that it has the strength of steel work and the impermeability and indestructibility of cement. The principle of combining two materials mutually to assist each other is not new, and we have seen it in the trussed cast-iron girders of Fairbairn and Stephenson, where one material of great compressive strength and another of greater tensional strength are applied, each to its utmost advantage. In reinforced concrete the component materials are more intimately combined, and while there are no visible joints or portions liable to work loose, the whole is encased in a material resisting dampness and atmospheric action. It is this last feature which, more than anything else, attracts the man who has to deal with steel and ironwork in situations where the air is charged with moisture, chemical fumes and smoke.

(To be Concluded)

# THE CARBON-MONOXIDE GAS PRODUCER

By W. Y. Lewis

DURING an experience of many years in connection with the undertakings of a firm which has recently completed some important engineering works in and about New York City, the writer has had repeated opportunities and occasions to investigate the advisability of installing gas engines and producers for the generation of power in connection with contracting works, such as docks, harbours, tunnels, etc., also for waterworks, cement mills and other industrial establishments. In many cases, however, the gas-power proposition has had to be rejected, notwithstanding the great saving in fuel which would have been effected, the cause for this decision being uncertainty as to its reliability, the feeling being too strong that the gas plant could not be depended upon to stand up to the work and run continuously under various conditions of loading to the same extent as a steam plant.

As an example in point, emphasizing that absolute continuity of operation and dependability is more important than thermal efficiency, the case of the large air compressing plant used in the construction of the East River tunnels in New York City may be cited. The writer found that, though it was not advisable or practical at the time to install gas-driven compressors and other machines instead of the steam plant adopted, a saving of apout $400,000, largely in coal consumption, could have been effected in the three and a half years that this plant was in operation. In this connection an interesting point came up, which is not as fully appreciated as it might be when advocating the use of gas-producer plant in preference to steam-boiler plant. The question arose as to the detrimental effect of the carbon dioxide given up in the exhaust from the gas engines to the surrounding atmosphere, which was the source of air supply furnished to the men working in the tunnels under the compressed air supplied by the compressing plant. Instead of being a point against the gas engine proposition, this was really in its favour, as the quantity of carbon dioxide therefrom would have been only about 20 per cent. of the amount given off by the steam boiler stacks, which also would give off a considerable quantity of carbon monoxide gas—an even more objectionable feature of the steam boiler in this aspect. This feature of the gas power plant is one which has a favourably important bearing on the health of factory employees and the cleanliness of the surrounding neighbourhood.

About twelve months ago, however, the writer became convinced that the gas-producer plant had reached such a stage of reliability that it could be depended upon to equal a modern steam equipment in every respect, and he came to this conclusion only after closely watching for over nine months the operation of a plant in which the combustible portion of the gas consisted solely of carbon monoxide. The plant, installed in the works of the John Thomson Press Company, in Long Island City, includes a producer in which no steam whatever is used, the gas containing practically no hydrogen, the result being an entire freedom from the usual diffi-

culties. This is evident when it is understood that it has been operated for a period of eighteen months on extremely varying loads, without any trouble with the engine as regards back-firing or pre-ignition, and without the producer fire having been once pulled.

Doubtless the producer gas engine business has received a serious setback in the United States by reason of the over-sanguine and unwarranted claims made by manufacturers and salesmen in their efforts to obtain orders, especially with respect to freedom from periodical shut-downs for cleaning fires.

It is true that there are several down-draught, bituminous-coal gas producers, as well as many pressure and suction anthracite gas producers working with success; but the operation of them involves considerable difficulty and features distressing to the operators and the management. It is, for instance, an absolute necessity to pull the fires at least once a week—often every fifty hours or so—on all down-draught plants. This is a laborious, troublesome and expensive proceeding, which the writer considers should not exist if the gas plant is to be considered as reliable and easy to operate as an ordinary steam plant. It is not possible with any of the above-cited producers, generating a composite gas, to run continuously for more than comparatively short periods at normal loads. If the load is variable—which is, of course, usually the case—troubles of a very objectionable nature, such as pre-ignitions and back-fires, appear in the engine. Consequently, as most services which the producer-gas engine outfit is required to meet involve load changes and other irregularities, difficulties ensue, because the composite gas, as made in most producers, cannot, owing to its inherent defects when generated from American fuels, be said to meet all the requirements. The fact that the status of the gas-power industry in the United States is so far behind the times, when compared with the situation in Europe, substantiates these broad assertions.

Why is it, then, that so little application has been made in the United States, whilst in Europe the producer gas-driven engine may be found in every hole and corner doing excellent work? Why is it that the outfit is so much easier to manipulate and is largely free from the troubles experienced in America? These questions are broadly answered by going back to the nature of the fuel available. Whereas in Europe the anthracite, for instance, is composed almost entirely of pure carbon, the percentage of ash being as low as 3 per cent., in the United States the anthracite contains ash running as high as 18 per cent. Moreover, if this high percentage of ash were not in itself sufficiently detrimental to the easy and successful use of anthracite in similar producers, the ash is of a fusible nature, as it contains iron, sulphur and other ingredients, which, unless the temperature of combustion be kept well below the melting point, cause very serious clinkering. This results in great difficulty with the operation of the producer, periodical shut-downs to pull fires being necessary, and continuous variation in the composition of the gas existing, with resulting troubles in the engine. Similar difficulties appear to an even greater extent in the case of down-draught and pressure-producers trying to use bituminous fuels of high grades; still more when the lower grade of bituminous fuel, lignites and peats are used, whereby the difficulties are enhanced by the excessive proportion of moisture present in the fuel and the tar given off in the gas.

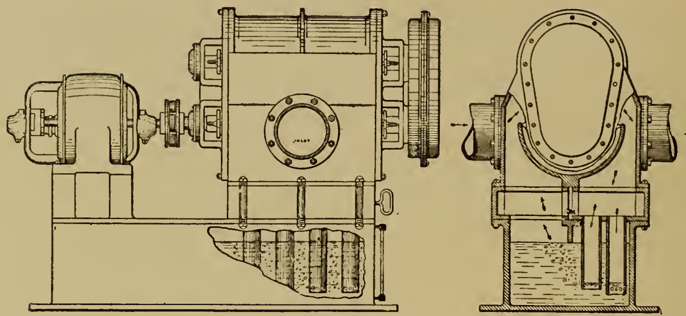
It is, consequently, essential to install in most cases an additional producer, so that a standby is available for laying off periodically to clean fires, etc., in cases in which the continuous operation of the engines is essential. The necessity for a duplicate producer plant, as well as large gas holders for storage purposes, and other accessories greatly enhances

CARBON MONOXIDE GAS PRODUCER AT THE WORKS OF THE JOHN THOMSON PRESS CO. THE GAS POWER CO., NEW YORK

the cost of the gas-producer plant, and renders its comparison with the steam plant less favourable.

The apparent solution of these difficulties lies in the use of what may be called a straight carbon-monoxide gas, this enabling all the troubles attendant upon the generation and use of a composite gas, due to the employment of steam or the vapour of water in its manufacture, to be eliminated.

This process comprises the use of a portion of the exhaust gases from the engines as a diluent instead of the water-vapour or steam usually fed through the grate bars with the necessary amount of air required to support combustion of the fuel in the producer. The effect of this is that the carbon dioxide fed to the fire is converted into carbon monoxide and given off with the additional quantity of carbon monoxide generated in the



THE TAIT EXHAUSTER AND AUTOMATIC PRESSURE REGULATOR

process of gasifying the fuel. As no water vapour enters into the process, the resultant gas is free from hydrogen (except that supplied by the fuel employed), being, therefore, composed practically of the one active constituent, namely, carbon monoxide.

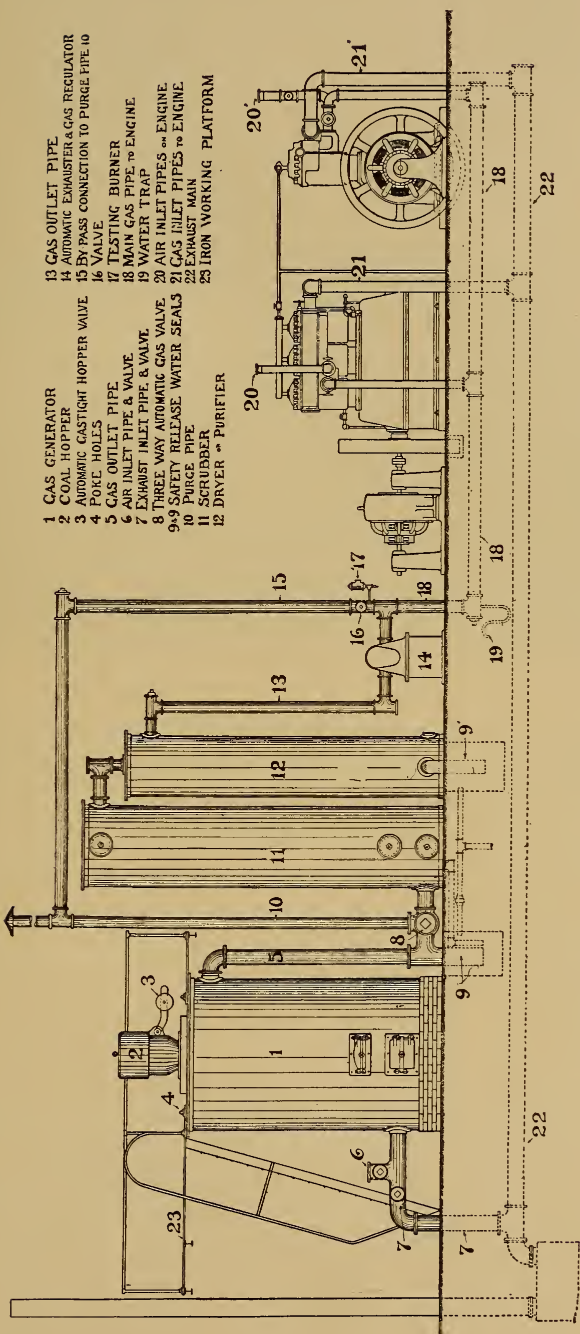
This process of regulating the temperature of combustion is surely one of the most important discoveries in the art that has been made in many years. It is being applied, with remarkably successful results, in various industries wherein the combustion of fuel and the application of heat plays a prominent part. It certainly has come to the rescue of the producer-gas outfit by dispelling the supposition that unreliability and inability to operate continuously were inherent defects and disadvantages of the gas producer. The John Thompson Press Company's plant and the Phœnix Tube Mill plant, in Long Island City, are examples of what may be achieved by this method of operation, and certainly possess many superior points, including reliability, over any steam installations in existence. It is interesting to compare these little plants with the enormous power plants of the New York Edison and the Pennsylvania Railway power stations, situated within a short distance of them. These enormous plants, equipped with the most modern and expensive steam turbines using high-pressure steam, superheaters, economizers, etc., consume nearly twice as much fuel per horse-power-hour, and certainly are not as free from troubles as the little producer plants above mentioned.

There seems to be no reason why the suction producer using a gas having a fixed ignition point and uniform quality will not, in a short time, render the pressure type of producer almost obsolete. It also has advantages over the well-known but complicated down-draught bituminous fuel apparatus, wherein is generated a variety of gases at different periods (by periodical manipulation of the steam blast—a cumbersome thing at the best—as a means of using bituminous fuel in gas producers).

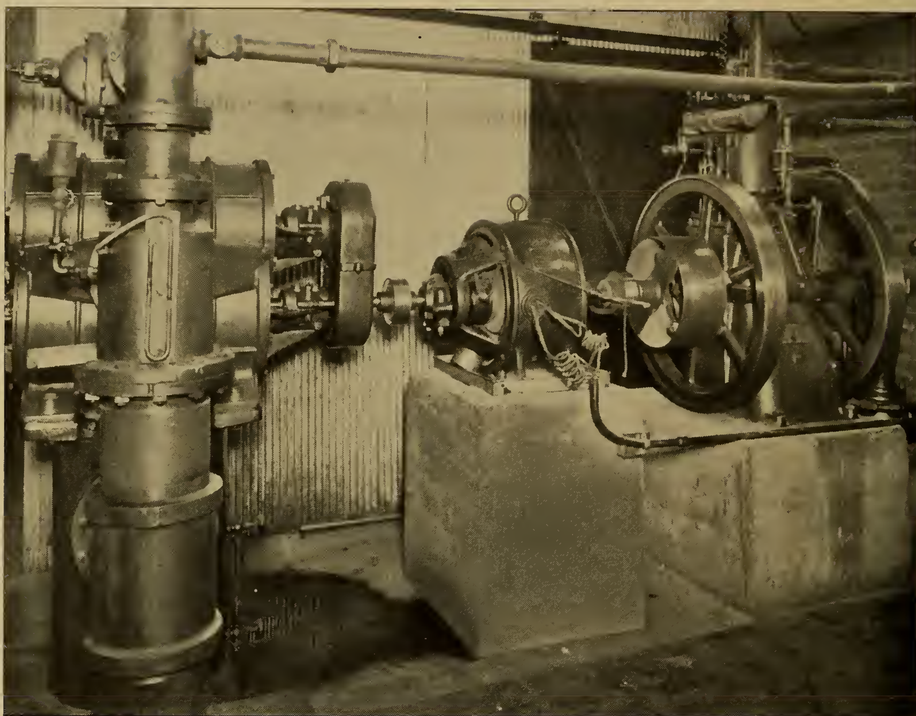
After considerable investigation into the present apparatus now on the market for generating gas with bituminous and low-grade fuels, the writer is of opinion that this process will be found capable of overcoming many of the difficulties encountered and not altogether mastered by previous processes.

The advantages of a straight carbon-monoxide gas of a constant low value, such as has been obtained as a result of such researches, may now be enumerated.

In the first place, attention is directed to the illustration indicating the layout, with marginal references to the items comprising the complete installation. It will be noticed that there is no duplicate gas generator, nor any steam boiler, evaporator, gasholder, nor any of the automatic de-




GENERAL ARRANGEMENT OF CARBON MONOXIDE GAS-PRODUCER PLANT. THE GAS POWER CO., NEW YORK



GAS EXHAUSTER AND AUTOMATIC PRESSURE REGULATOR. THE GAS POWER CO., NEW YORK

vices usually found in producers using steam or water-vapour. The producer marked *1* is merely a shell lined with fire-brick, having a simple charging hopper and sight or poke-holes at the top and an air inlet marked *6* at the bottom, having a T-connection through a valve marked *6* and *7* with the exhaust from the engines for the purpose of leading a certain proportion of the exhaust gases under the fire bars, admixed with the necessary air required to support combustion. An ordinary wet scrubber, marked *11*, is provided, and a purifier, marked *12*, is shown, though hardly necessary. At *14* is shown a blower superimposed upon a device, the function of which is very important. This exhauster draws the gas from the producer and delivers it under a pre-determined pressure to the engines. The delivery pressure is maintained absolutely constant, no matter how the load varies, by means of the water-seal arrangement in the box beneath, a short-circuiting valve being provided should it at any time become necessary to cut out the blower and permit the engines themselves to draw the gas direct from the producer. This device appears to the writer superior to any arrangement of flap valves and by-passes, and its advantage lies in the fact that it does maintain a remarkably steady and constant pressure on the engine without the use of any mechanism. A separate cut of this is shown in Fig. 14, from which it will be readily seen how this device operates. The blower can be operated by the engine or by a small gas or gasoline engine or electric motor, and be governed by the pressure of the gas on the delivery side.

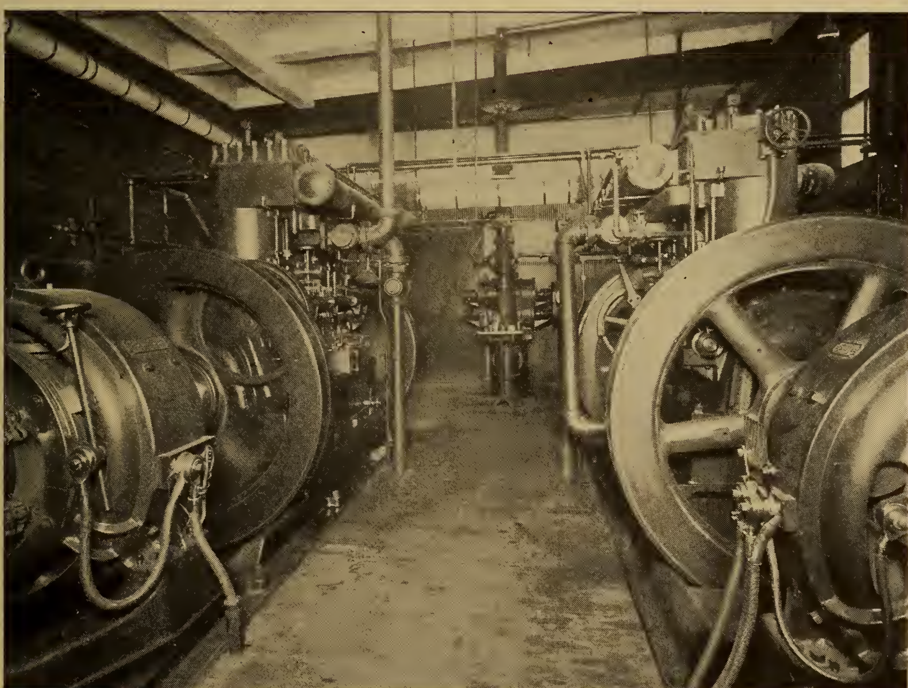
The advantages of this process, as regards the producer itself, are: the pulsating effect of the exhaust gas entering with and inducing the required air supply at *6* and *7*. This

results in a beneficial shaking action on the ashes and keeps the air streams well distributed throughout the fuel bed.

The maintenance within a quarter of an inch of an atmospheric balance in the ash-pit and in the space above the fuel bed is important, since it permits the ash-pit doors to be kept open without a detrimental influence upon the generation of the gas. Likewise, the poke-holes in the top of the producer can be kept open for quite a considerable time, facilitating the periodical operation of poking the fuel bed where it comes in contact with the lining of the producer shell. It should be noted that it is not necessary in firing the producer to poke the fuel bed for the purpose of breaking up clinkers and ensuring draught circulation, but that all the poking necessary is by means of a slice-bar or chisel-shaped poker around the periphery of the fuel bed to prevent the hot fuel in the combustion zone from sticking to the refractory lining.

It is remarkable that when the ash-pit doors are opened, whilst the producer is in full operation, a handkerchief held suspended by the door indicates no inclination to be sucked in or blown out. Consequently, there is not the slightest necessity for the troublesome water-seal usually found in the ash-pit of many designs, as ashes can be drawn at any time with impunity. So in the case of the poke-holes at the top, there is no objectionable rush of gas out, to the annoyance of the stoker; neither is there any dangerous rush of air inwards, so that the state and condition of the fire can be watched and manipulated conveniently and at any time.

The reaction of carbon dioxide in passing through the combustion zone in a certain known percentage is found to be endothermically effective in keeping the temperature of the combustion below the clinkering temperature. In using a fuel high in fusible ash, this is an absolute necessity, and it is this which renders it



ENGINE ROOM. JOHN THOMSON PRESS CO., LONG ISLAND CITY

possible to run a single producer for months continuously at full load without having to pull fires, a performance never in common knowledge, if ever, accomplished when vapour or steam is the diluent employed.

The uniformity of the gas and its ignition point generated is remarkable, no matter how the load varies. The percentage of carbon monoxide in the gas remains practically uniform, and as there is no varying hydrogen constituent, the calorific value remains practically the same, irrespective of the demand for gas.

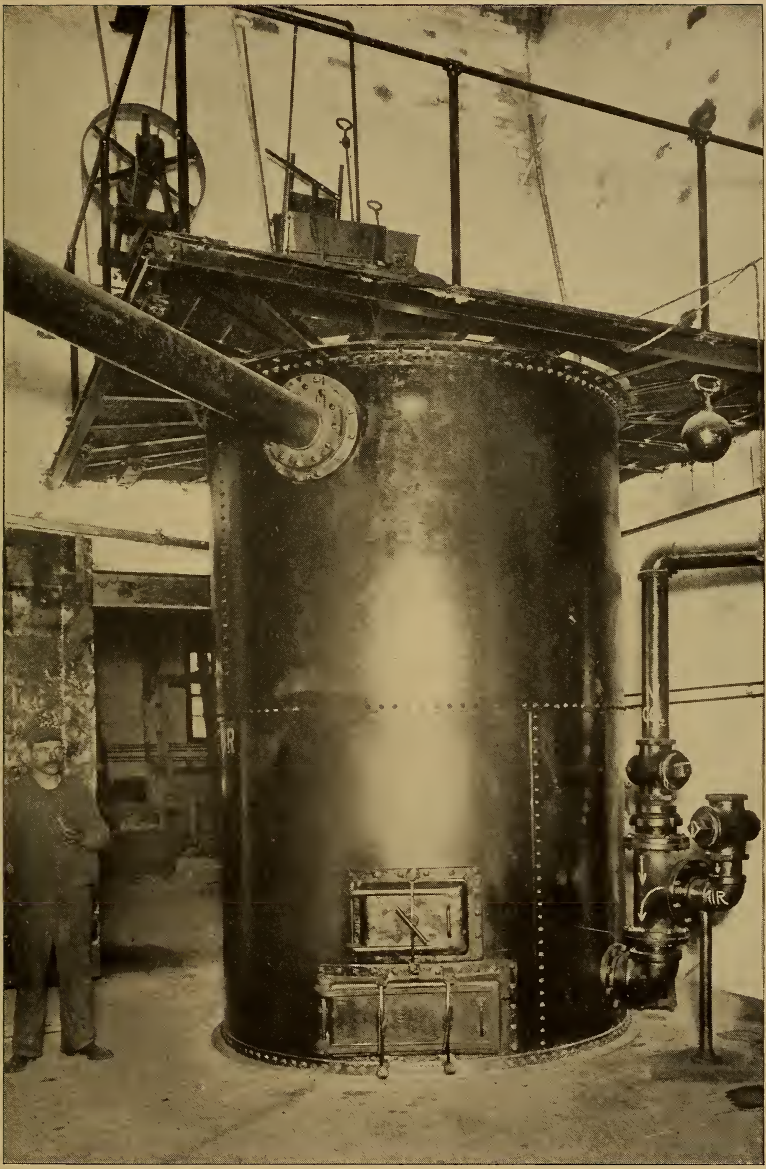
In several pressure and suction producers now on the market a more or less successful attempt is made to regulate automatically the amount of steam or water vapour admitted in proportion to the load. This, however, is a makeshift to remedy a defect instead of removing the cause, and it will be recognized that such devices are complications unnecessary in a producer making straight carbon-monoxide gas.

Another favourable feature of this producer is that any number of engines can be supplied by a single suction producer without the use of a gas-holder. This is not the case with other types of suction plants, except, perhaps, when engines have "hit - and - miss" governors, which, however, may be dismissed as of little bearing on the point.

The producer does not consume any water, thereby effecting a considerable saving, amounting to about half a pound of water for every pound of coal consumed. This is a great feature of the process for marine work or salt water, or where water has to be purchased from the city.

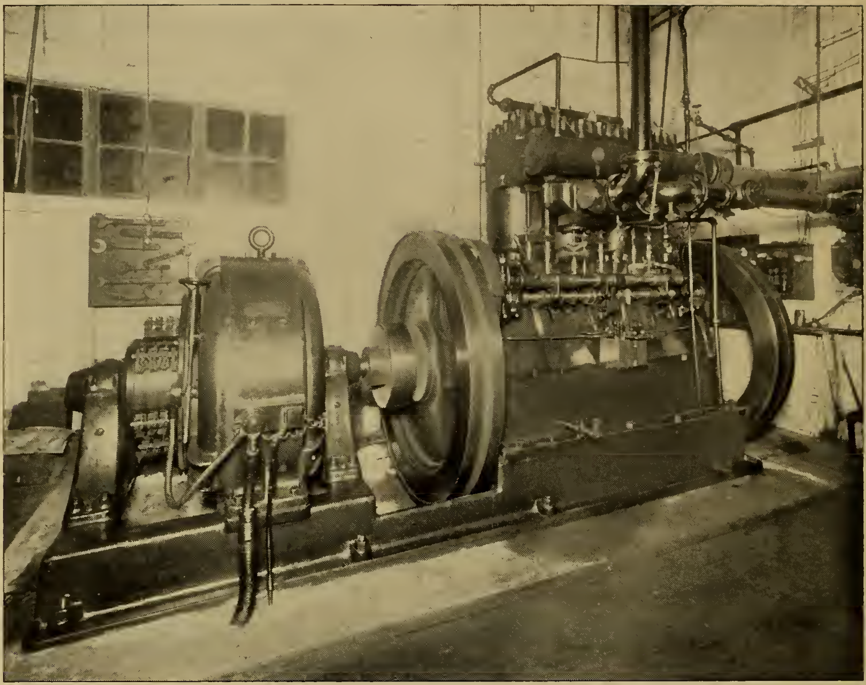
It is claimed for many types of producers that hydrogen is a valuable constituent in the gas generated, inasmuch as the calorific value is increased in proportion. Now considering that the amount of draught is proportional to the load it determines, the temperature of the combustion zone, and the fact that only partial dissociation of steam takes place at low temperatures and, therefore, at low loads, it is clear that at high loads more of the steam admitted will be dissociated, owing to the consequent higher temperature of the combustion zone, and the result is a great variation in the percentage of hydrogen under different loads. Consequently, the heat value per cubic foot changes, and, what is even more objectionable, there is a change in the relative proportion of the active constituents of the gas, namely, carbon monoxide and hydrogen. Then at high loads, when the percentage of hydrogen is a maximum, the ignition point has to be set for hydrogen, because its rate of combustion is about twice as fast as that of carbon monoxide, with the result that it is too late to derive the full benefit from the carbon monoxide constituent. Again, when the load is light, the percentage of hydrogen drops almost to a negligible quantity, leaving as the still more important constituent the carbon monoxide to be ignited at the wrong time—namely, that previously set for the hydrogen constituent—with a result that but little effect is obtained. It would seem, therefore, that in the composite gas, whilst the carbon monoxide constituent is always of greater thermal value, its welfare and usefulness in the engine cylinder are sacrificed in the interest of the hydrogen constituent, whose presence and behaviour is somewhat fickle, and certainly not worthy of the consideration and encouragement it has received to be present in the producer gas.

Obviously it is not possible to change the ignition point satisfactorily to correspond with the varying percentages of hydrogen, although a very ingenious arrangement has been devised for this purpose. With a gas of lower calorific value, but of such uniform composition that the ignition point can be set at exactly the right position and kept at the



GAS PRODUCER AT THE PHŒNIX TUBE COMPANY'S WORKS. 250 HORSE-POWER, OPERATING TWO ENGINES IN PARALLEL

same point, and with the certainty that the carbon monoxide, being the only active constituent of the gas, will be ignited every time without fail, the same engine using this gas will generate even more power (due to its more correct adjustment) than it would when using the composite gas improperly ignited. The value of the gas furnished by a producer generating a carbon-monoxide gas remains generally constant at about 105 British thermal units when using anthracite coal. In the case of composite gas, the calorific value varies continually between 120 and



NASH GAS ENGINE AND C. & C. DYNAMO AT THE PHŒNIX TUBE COMPANY'S WORKS USING STRAIGHT CARBON-MONOXIDE GAS

145 British thermal units per cubic foot.

It has been urged by many gas-producer builders and their salesmen that the hydrogen element in the gas generated by the producers is an advantage. There can be no doubt, however, that the hydrogen element in practice has been a source of much annoyance. Although many eminent engineers still maintain that pre-ignition and other troubles are not due to the presence of the hydrogen constituent, the fact remains that, in all engines using a straight carbon-monoxide gas, pre-ignitions are unknown. As a matter of interest, the writer received a letter from Prof. Dalby recently, wherein he says that, even in England, all the gas people are on the track of working with a lower-value gas, indicating a desire to cut out the hydrogen, and the same tendency is evident in America.

Another good feature of a gas having but one active constituent (CO) is the fact that it can be compressed to a higher initial pressure than a gas containing high percentages of hydrogen, without fear of premature ignitions.

Some of the more recent researches in England as to the value of high compressions are claimed to indicate that the efficiency is not enhanced by excessively high compressions; but in the case of engines which have been converted from the use of the composite gas to the use of the straight carbon-monoxide gas, it has been found possible to increase the compression from 20 to 60 per cent., with greatly improved results in all respects.

Another valuable feature of using a gas containing only carbon monoxide is that the engine exhaust gases can be used in water heaters, due to the absence of corrosive acid ($H_2SO_3$), whereby a great saving can be effected in utilizing the heat usually thrown away in the exhaust.

A sufficient amount of heat can then be obtained to generate steam, or heat water, for warming a factory, either on the hot-air, steam or hot-water system. In the ordinary kind of gas-producer outfit, wherein steam instead of the small percentage of exhaust carbon dioxide is used in the process, this has not been found practicable, owing to the fact that the sulphur from the fuel combines with the hydrogen gas and forms sulphurous acid, which quickly eats away any type of heater which might be used. There are many cases known to the writer illustrating this unfortunate objection, and this point has been much against the producer-gas outfit in propositions embodying the heating of the factory, as well as the power supply. The use of the straight carbon-monoxide producer is the solution of this difficulty, as the exhaust gases from the engine contain nothing injurious to the materials of which such heating apparatus is usually constructed. Doubtless this feature will carry much weight with the prospective purchasers intending to equip factories with gas-power plants, as there is no maker of the usual form of either pressure or suction producers known to the writer as being willing to undertake the heating of the factory by heat derived from the engine exhaust.

It would seem, therefore, as though the gas engine has a strong preference for the straight goods (CO), just as the canny Scotchman likes his whiskey, yet with infinitely better resulting behaviour. In all probability this process of making CO gas is not entirely new to the readers of this magazine, as the matter has been treated in several articles by the originator, Mr. Godfrey M. S. Tait, to whom the writer believes the gas-power world owes much more than it probably realizes at present. However, it may be that the advantageous features of this method of producer operation and the gas resulting have not been sufficiently brought forth. In accordance with this supposition, it occurred to

SCRUBBER, PURIFIER AND GAS REGULATOR AT THE WORKS OF THE PHŒNIX TUBE CO.

the writer, whose experience in gas engines goes back to the days when the Crossley engine had slide valves and flame ignition, and in France when the poor-gas suction producer, using Welsh anthracite, was being developed, previous to its introduction to London about eight years ago, that a more comprehensive treatment of this producer and the straight carbon-monoxide gas, in comparison with the better-known producers and the composite gas generated thereby, would be of serviceable interest to the profession and to the gas-power world in general.

The following table gives a comparison of typical analyses of producer gases made under the two methods of producer-gas operation:

COMPOSITE GAS-PRODUCER USING STEAM OR VAPOR.

| | | Per Cent. |
|---|---|---|
| CO | Carbon monoxide | 19.8 |
| H | Hydrogen | 15.1 |
| $CO_2$ | Carbon dioxide | 5.8 |
| $CH_4$ | Marsh gas | 1.3 |
| N | Nitrogen | 56.7 |
| O | Oxygen | 1.3 |
| | High calorific value, 136 B. T. U. | |

There is a possible variation in the hydrogen constituent between 5 to 18 per cent., depending on fluctuations of load.

STRAIGHT CARBON-MONOXIDE GAS PRODUCER USING EXHAUST GASES

| | | Per Cent. |
|---|---|---|
| CO | Carbon monoxide | 26.95 |
| H | Hydrogen | .20 |
| $CO_2$ | Carbon dioxide | 1.75 |
| $CH_4$ | Marsh gas | .50 |
| N | Nitrogen | 69.30 |
| O | Oxygen | 1.30 |
| | Calorific value, 105 B. T. U. | |

This gas remains uniform in composition under all conditions of load.

# THE STORAGE AND HANDLING OF COAL AND ASHES IN POWER PLANTS

By Werner Boecklin

IF the cost of moving coal and ashes by hand in a power house exceeds by an appreciable amount the cost of doing it by machinery, then the installation of a system for the service is worth considering. The total amount of material handled in a year serves as a key to determine the amount the owners are justified in expending upon an equipment. It is of importance to know at the outset not only the relative first cost of various systems, but the approximate amounts to charge against labour, repairs and supplies, in order to arrive at a fair comparison between equipments available in a given case.

In many instances the problem of selecting a general plan, and choosing between the various details which offer in the working out of such plan, is a complex one. This may be realized by glancing over the following items, all of which need be considered by the engineer when designing a plant:

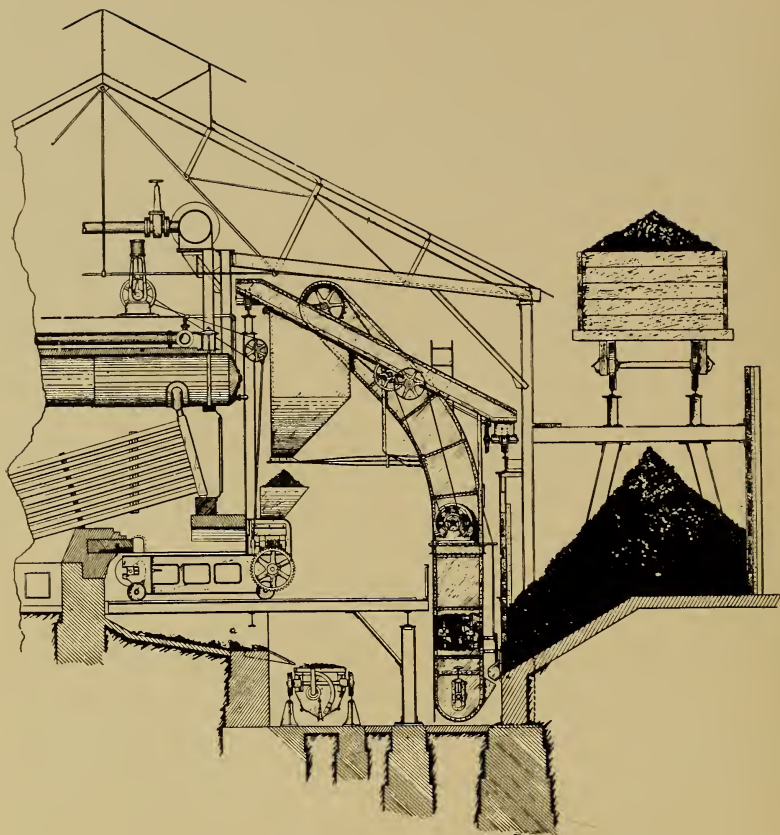
Capacity of plant in tons per day.
Water or rail delivery.
Distance from either.
Amount of current storage.
Amount of energy storage.
Method of storage to be adopted.
Crushing machinery to be used or not.
Kind and arrangement of boilers.
Stokers to be used or not.
Scales to be used and type.
Ash hoppers provided under boilers or not.
Final disposition of ashes.
Capacity of ash storage, if any.
General character of building.
Amount of capital available.

In selecting machinery it is better to determine upon sizes and speeds which will give required capacities under all ordinary working conditions, and allow, at the same time, a certain amount of leeway to provide for contingencies which are certain to arise.

Location of plant has a controlling influence upon the general plan for coal and ash-handling. A waterside power plant, for example, receives one sort of treatment, and a plant depending upon rail delivery a totally different one. In both classes the general plan is further modified by the distance of boilers from the unloading point. A certain system is well adapted to a plant located directly on a body of water or railroad line, whereas the same system cannot be installed if the station is at some distance from the feeding point.

The question of storage is of twofold importance from the standpoint of the material-handling engineer, for not only must coal be placed in storage conveniently and economically, but it must be withdrawn with equal facility and as cheaply as possible. The mechanical system adopted for doing the work affects, to a greater or less degree, the cost of constructing the pockets or bins, and has a bearing also upon the matter of insurance against fires resulting from spontaneous combustion.

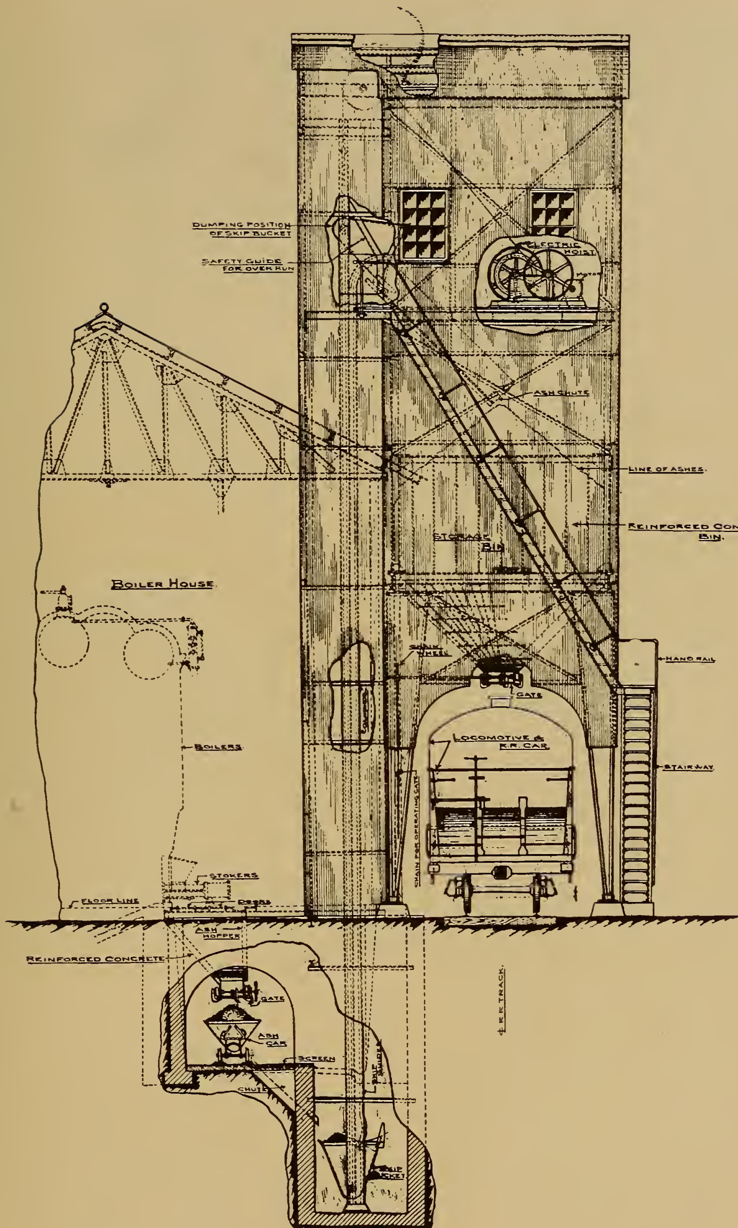
There are two classes of storage which may be provided for, viz., a current, or daily working storage, and a reserve, or emergency storage, to tide over strikes, freight congestion and bad weather conditions. In the first class either an inside or an outside storage is provided. With inside storage quantities of fuel are held in a central position, whence all



COAL AND ASH HANDLING EQUIPMENT AT CARNEGIE STEEL CO. PITTSBURG, PA. HEYL & PATTERSON, PITTSBURG, PA.

may be withdrawn for consumption at a minimum cost. Such storage bins have capacities in large stations measured by thousands of tons, running down to comparatively small pockets frequently built in old boiler houses where greater storage capacity cannot be secured on account of structural limitations. Where coal is stored outside, the danger to boiler house from fire is somewhat minimized, and the cost for structural steel is frequently lowered or eliminated altogether. Outside storage also secures a rapid and cheap delivery from the source of supply, particularly where coal comes by rail in bottom-dump cars which run over the storage pocket. With water delivery, the unloading charge is always present.

The two classes of storage may be combined in the case of outside pockets, thus eliminating certain portions of the equipment needed where the two classes are kept separate. This is a matter of importance, when it is considered that an auxiliary storage may be dormant for weeks at a time, the capital invested in this portion of the handling plant in the meanwhile accumulating up an interest charge and doing no work. Where ground storage is employed coal is delivered by means of conveyors, industrial cars, grab buckets, or direct dumping from railway cars, and is withdrawn by means of grab buckets or conveyors, or a combination of the two. Delivery to storage is a comparatively easy matter; withdrawal, however, is usually more difficult. To draw off, one or more tunnels may




GENERAL ARRANGEMENT OF COAL AND ASH HANDLING PLANT FOR BOILER HOUSE. HEYL & PATTERSON, PITTSBURG, PA.

be run the length of the pile and conveyors installed in them; a gantry crane, spanning the pile and carrying a grab bucket, may pick up the coal at any point and deliver to conveyor or cars; a locomotive crane is used for a similar service.

Where provision is made for large emergency storage the question of deterioration naturally arises. Tests

COAL HOISTING TOWER AT POWER STATION OF THE WEST JERSEY & SEASHORE RAILROAD, WESTVILLE, N. J
C. W. HUNT CO., NEW YORK

made in the Engineering Experiment Station at the University of Illinois show quite conclusively that submerged coal loses practically none of its heat value, and that coal stored outside, exposed to the usual climatic conditions, shows a tendency to "slack," and that heat values lost vary from 2 to 10 per cent. The storing of coal under water has gone no further than the experimental stage. The British Admiralty has been experimenting with submerged coal, and the Western Electric Company has facilities in its Hawthorne plant for storing 14,000 tons. Here the coal is dumped directly from cars into bins, which are then flooded until the coal is needed. Coal is withdrawn by means of grab buckets.

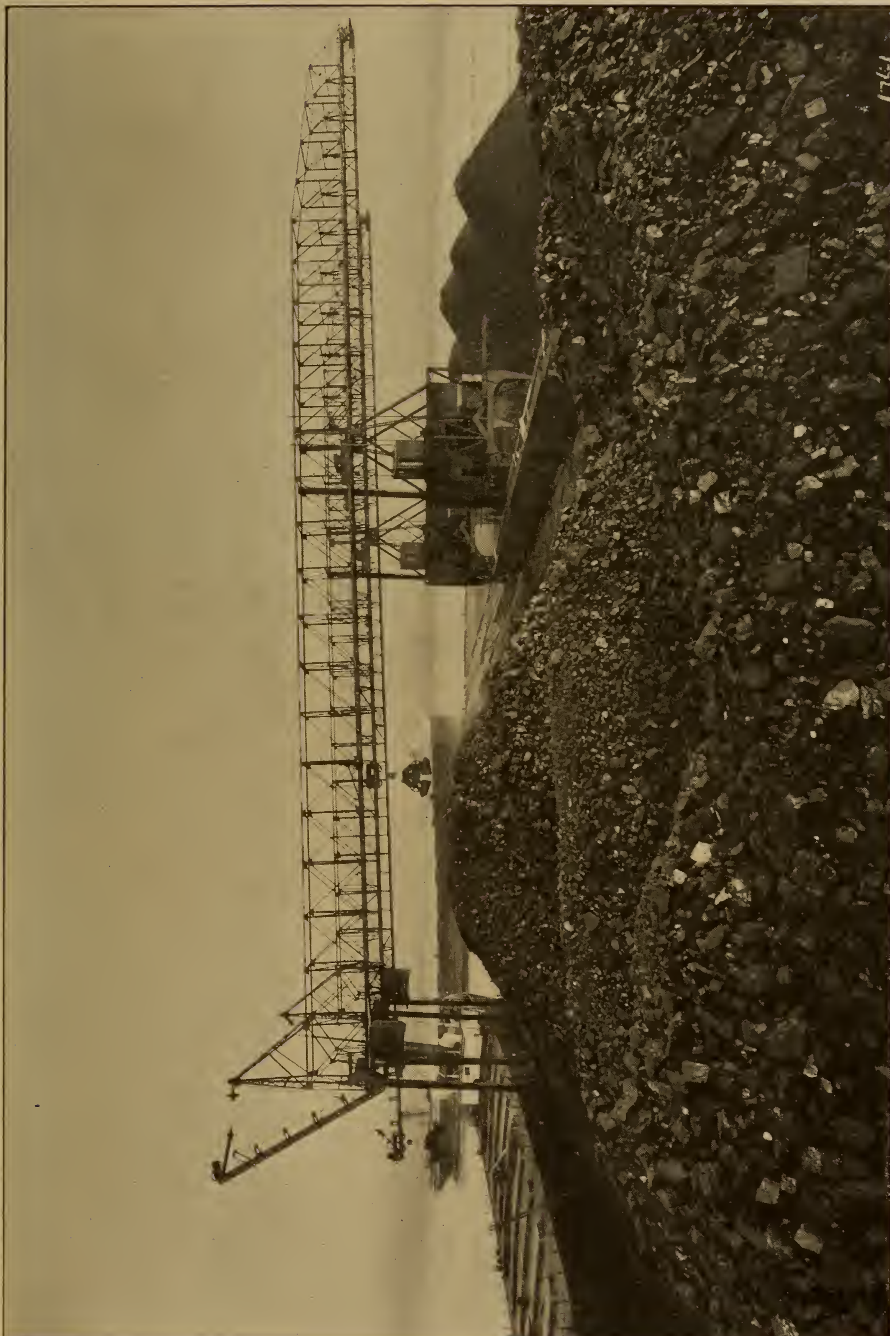
Usually coal is taken from unloading point to storage by means of automatic or semi-automatic equipment, distance of travel playing an important part. With comparatively long distances some form of industrial railway, as cable roads, automatic roads and electric trolley roads, is frequently employed, also telpherage and suspended cable installations.


COAL HANDLING TOWERS AT ASTORIA LIGHT, HEAT AND POWER CO., ASTORIA, L. I. REACH OF BOOM, 45 FEET OVER WATER, 108 FEET CLEAR OF TOWER OVER LAND. CAPACITY OF EACH TOWER 300 TONS PER HOUR. MEAD-MORRISON MFG. CO., NEW YORK

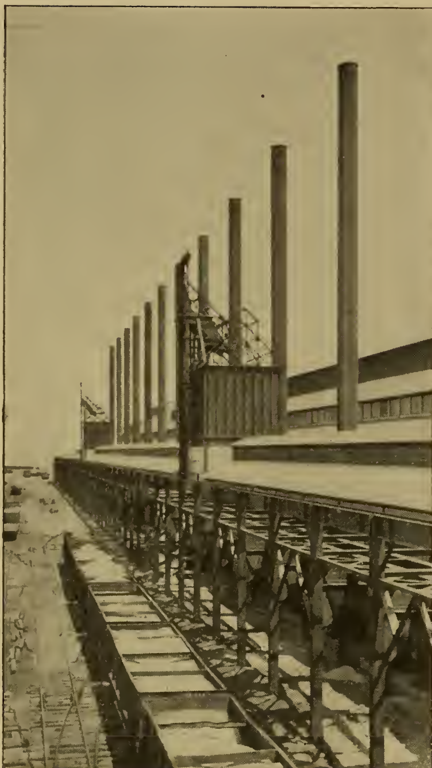
ELECTRIC TELPHERAGE SYSTEM FOR HANDLING COAL FROM STORAGE TO BOILERS. DODGE COAL STORAGE CO., PHILADELPHIA

Neither the telpherage nor the suspended cable system gives capacities possible with a cable road, and for this reason they are not generally used for this class of service. Where the distance from unloading point to storage is comparatively short, continuous handling machines are largely used. Such machines include the various types of conveyors and elevators on the market. Where there is sufficient space to install an inclined conveyor, either a belt or scraper conveyor is employed. If, for any reason, inclined conveyors cannot be used, a horizontal conveyor delivering to a vertical elevator, or a continuous machine having both horizontal and vertical runs, is installed. The division of service between two or more machines, as against the use of one machine, depends upon the general layout. In settling points of this nature the engineer must consider various matters at one and the same time: feasibility, strength of parts, operation, first cost and running expenses are all to be borne in mind.

In cases in which bottom-dump cars are largely used, a common method is to discharge them into a



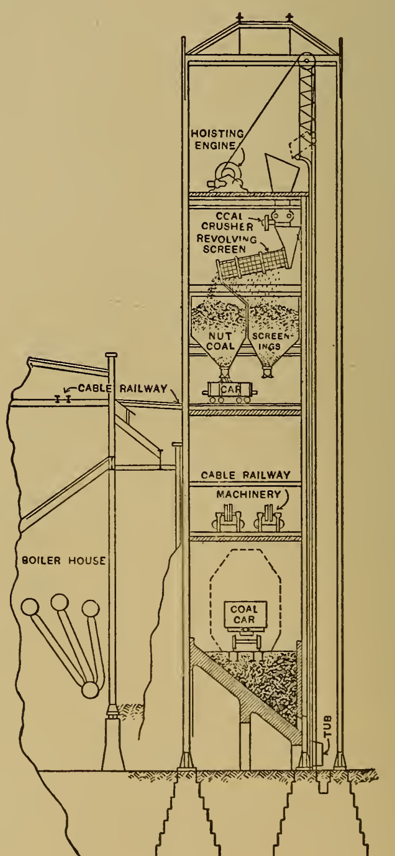
COAL HANDLING BRIDGE AT BOSTON COAL DOCK DULUTH, MINN. THE WELLMAN, SEAVER, MORGAN CO. CLEVELAND, OHIO



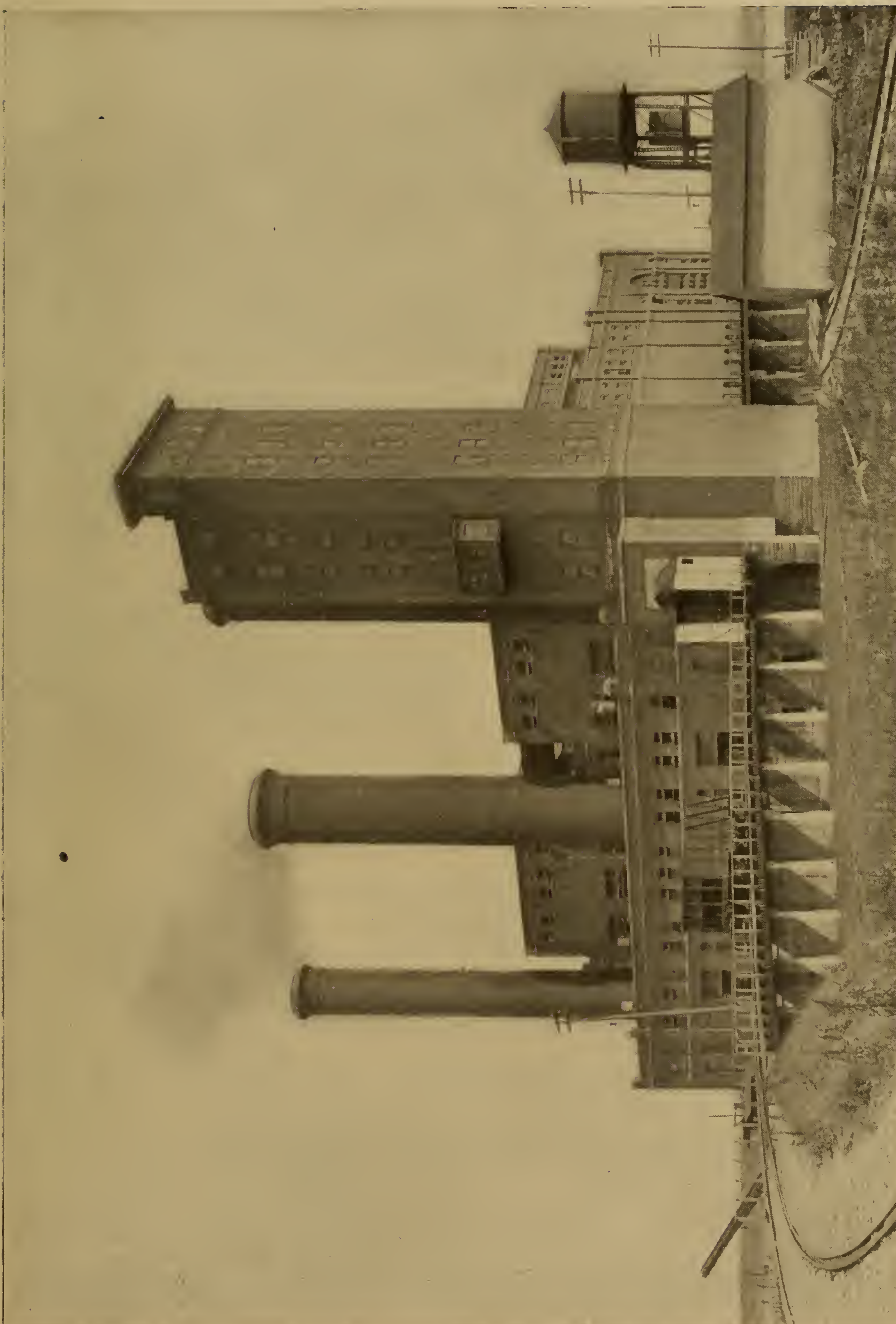
TRACK HOPPER, ELEVATOR AND COAL STORAGE BIN FOR AUTOMATIC COAL HANDLING. C. O. BARTLETT & SNOW CO., CLEVELAND, OHIO

steel hopper set in the track. This hopper may either deliver to some form of conveyor or elevator or to a coal crusher. If the railroad track crosses the axis of the boiler room at approximately right angles and is sufficiently near to the walls thereof, an efficient arrangement consists in extending the main conveyor over the boiler-room bunkers and out over the track, looping the track hopper. When this arrangement is not feasible, both upper and lower lines of conveyor may pass under the hopper, thus eliminating all overhead work outside the building. In the case where the delivery track is parallel, or nearly so, with the axis of the building and storage is overhead in the building, some form of cross conveyor is installed to carry coal from track to main conveyor over the storage bunker. Where storage is outside and the track is parallel with the building, if it is possible to elevate the track a comparatively cheap storage pocket can be built, and various means are available for taking coal from same. Where such elevated track is close to the building, the wall may be used as one side of the pocket and coal drawn off on boiler-room floor or into a suitable traveling elevator.

In all up-to-date boiler plants coal is weighed either at the receiving end of the system or at the boilers. A check is thus kept upon the total tonnage, and, where installed over stokers, the charges can be closely regulated, thus insuring economy in




SECTION OF TOWER AT DETROIT EDISON ELECTRIC CO., DELRAY, MICH
C. W. HUNT CO., NEW YORK



COAL HOISTING TOWER DETROIT EDISON ELECTRIC COMPANY, DELRAY, MICHIGAN. C. W. HUNT CO., NEW YORK

ASH CONVEYOR, CLEVELAND TWIST DRILL COMPANY, SHOWING ELECTRIC DRIVING AND SHIELD PROTECTING CONVEYOR WHEELS FROM DUST. C. W. HUNT CO., NEW YORK

CABLE CAR SYSTEM AT DETROIT EDISON CO., DUPLEX CUT-OFF VALVE DELIVERING COAL FROM OVERHEAD HOPPER TO CAR. C. W. HUNT CO., NEW YORK

ROLLER FLIGHT COAL CONVEYOR 300 FEET LONG AT PLANT OF CAMDEN COKE CO., CAMDEN, N. J.
R. H. BEAUMONT CO., PHILADELPHIA

firing. Boiler-room scales are either stationary or traveling. The former are usually attached to the overhead bunkers and serve a single boiler or a battery. For the latter a suitable track is attached to the bunkers, and the scales, with hopper and spout, are made to serve as many boilers as possible. Capacities vary from 100 pounds to 1,000 or more, depending upon the type, and are either automatic or non-automatic. A stoker charge is about 800 pounds, so scales of about 750 pounds capacity are commonly used. A device frequently installed as part of the scale and track equipment is a reloading chute. This is movable along the scale track, drawing coal from one part of the bunker for delivery to another part where supply has run low.

The ashes-handling problem needs fully as much consideration as that of the coal. Of the many materials now conveyed by special machinery, ashes are responsible for a large percentage of the troubles common to this class of machinery. We must contend with the cutting effect upon all moving parts—heat and its distorting action, flooding of machinery by quenching water, freezing of wet ashes and adhesion to machinery, and chemical action upon carrying parts.

STEAM-OPERATED HIGH-SPEED BRIDGE TRAMWAY. NEW YORK EDISON CO., SHADY SIDE, N. J. COMMANDS A STORAGE OF 50,000 TONS OF COAL. DODGE COAL STORAGE CO., PHILADELPHIA

AUTOMATIC RAILWAY OVER COAL BUNKERS. POWER STATION OF THE WEST JERSEY & SEASHORE RAILROAD, WESTVILLE, N. J. C. W. HUNT CO., N. Y.

REINFORCED CONCRETE COAL BUNKER AND 30-INCH BELT CONVEYOR UNDER CONSTRUCTION BY R. H. BEAUMONT CO., FOR CAMDEN COKE CO., CAMDEN, N. J.

Two general divisions may be made of the problem—one where the same machinery which delivers coal to storage over the boilers removes the ashes to convenient disposal point, the other where a separate system is installed for handling the ashes. In the large modern power houses ashes are dropped into pockets under the boilers, where they are wet down before being discharged through a gate or valve provided for that purpose. In cases where a station is being revamped and no basement or suitable passageways exist for handling ashes in this manner, they may be drawn by hand and dropped into a conveyor under the floor or shovelled into industrial cars or bucket handled by overhead track system. Keeping ashes off the boiler-room floor and taking care of them in a basement provided for the purpose gives unquestionably the best results, and means should be provided in all large plants for handling in this way.

In a symmetrically-arranged plant where ash pockets are installed, it is frequently advisable to use the coal conveyor for carrying away the

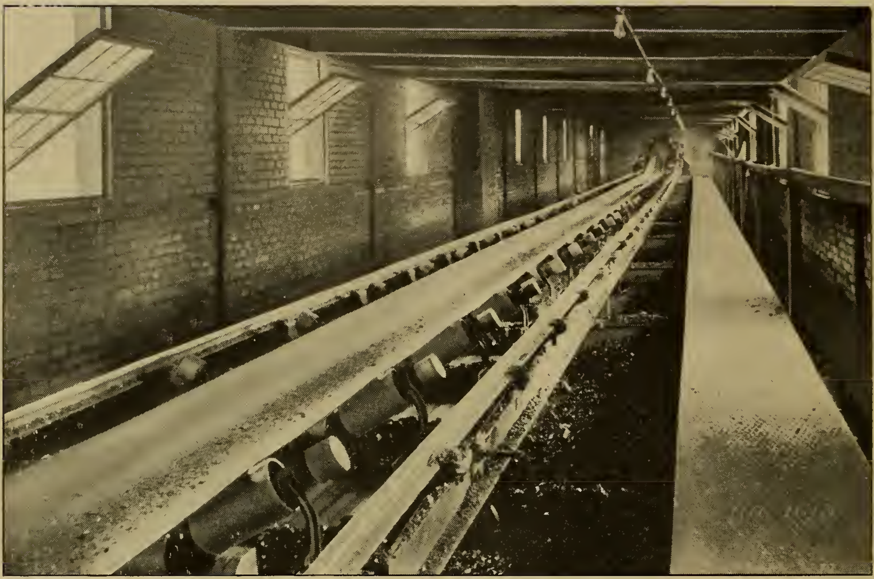
COAL STORAGE PLANT OF MICHIGAN ALKALI CO., WYANDOTTE, MICH. LOCOMOTIVE CRANE ON 20-FOOT GAUGE TRACK. DODGE COAL STORAGE CO. PHILADELPHIA

COAL STORAGE PLANT OF LACKAWANNA STEEL CO., BUFFALO, N. Y. ELECTRIC LOCOMOTIVE CRANE. DODGE COAL STORAGE CO., PHILADELPHIA

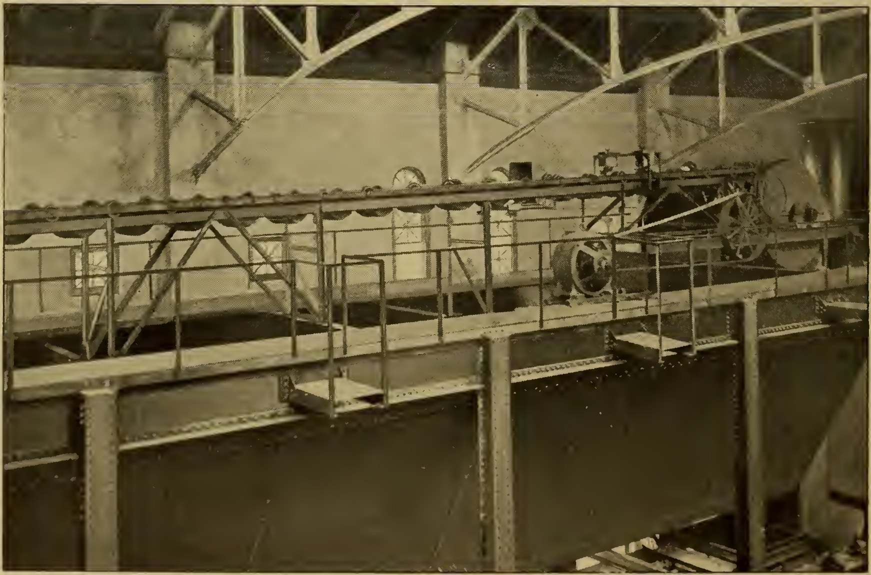

COAL HOISTING TOWER AT THIRD AVE. POWER HOUSE, BROOKLYN HEIGHTS RAILWAY CO TOWER IS EQUIPPED WITH 1½-TON SELF-FILLING BUCKET, WEIGH-SCALES AND CRUSHERS. DODGE COAL STORAGE CO., PHILADELPHIA

ashes. In such an arrangement the gravity-bucket type of machine is the only one to be considered. This conveyor forms a continuous loop, the upper run delivering coal to the overhead bunkers and the lower run carrying ashes to a convenient discharging point. In the design and installation of such a system great care should be exercised to adopt suitable means to keep the ashes away from the running parts.

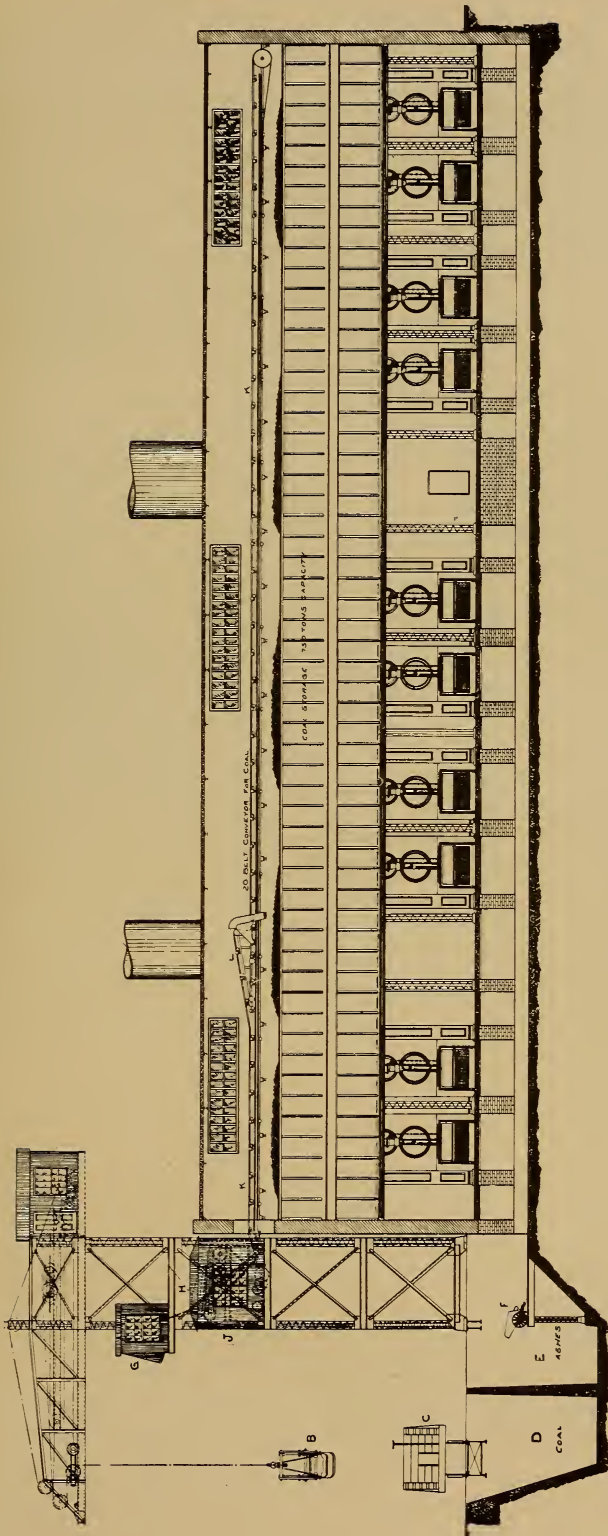
Where a separate system is employed there are various economical methods for doing the work. The service is divided into two parts, viz., conveying ashes away from pockets under boilers and delivering them to suitable storage pockets. Industrial tracks for transporting dumping ash cars are extensively employed. Such tracks, running under a line of ash pockets, lead to a dumping point where the ashes are elevated to storage. An overhead track system may be used carrying suspended buckets. Such systems are operated by hand or power. Electric traction locomotives of the storage-battery or trolley type are used for handling cars, and trolley traction is employed on overhead systems. In the case of electric trolleys there is always the disadvantage in having an exposed conductor, particularly in a confined space under boilers, where head room is usually low and wire is within easy reach. For this reason the



PEORIA GAS AND ELECTRIC CO. JEFFREY BELT CONVEYOR CONVEYING COAL



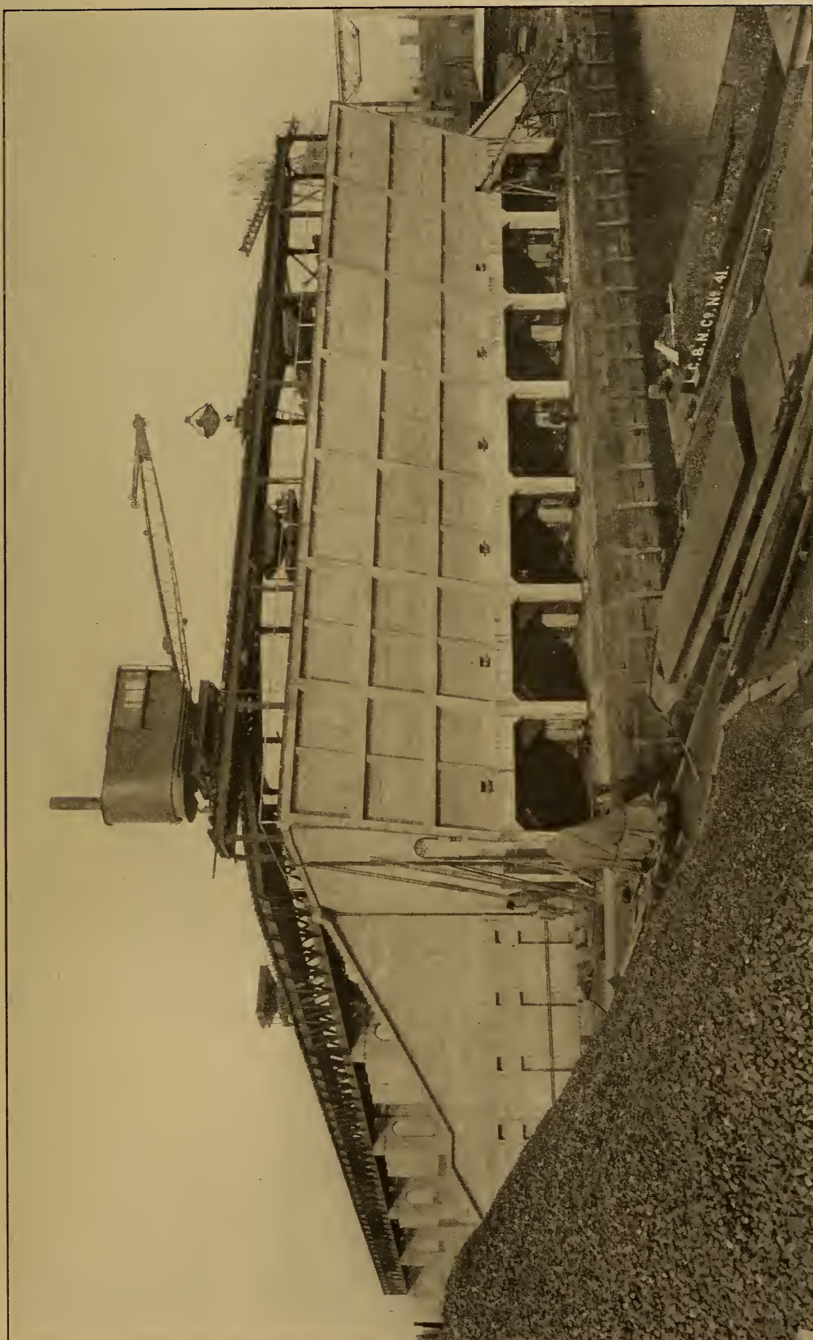
NEW ORLEANS WATER PURIFICATION PLANT. PIVOTED BUCKET COAL CONVEYOR AND STEEL TRACK HOPPER. JEFFREY MFG. CO., COLUMBUS, OHIO




PEORIA GAS AND ELECTRIC CO. GENERAL ARRANGEMENT OF GRAB BUCKET AND BELT CONVEYOR SYSTEM FOR COAL HANDLING. JEFFREY MFG. CO., COLUMBUS, OHIO

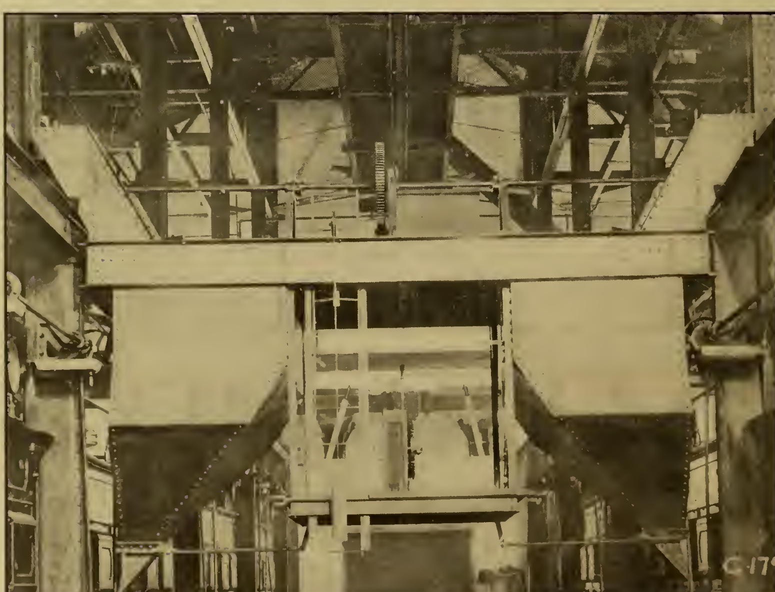
PEORIA GAS AND ELECTRIC CO., TOWER AND GRAB BUCKET TAKING COAL FROM CARS AND DELIVERING TO CRUSHER AND BELT CONVEYOR JEFFREY MFG. CO., COLUMBUS, OHIO

storage-battery locomotive commends itself for such service, as it is absolutely safe and is economical to operate. Where the cars are to be pushed bv hand, it pays to have them equipped with roller bearings, in order to reduce journal friction as much as possible and thereby cut down the amount of labour needed in shunting cars. Where cars or suspended buckets are used, either a "skip" or bucket elevator is installed for delivering ashes to storage or into cars or boats. In the case of skip hoists it is common practice to dump ashes directly into the skip car without the intervention of any receiving hopper. With bucket elevators, however, a receiving hopper, which feeds the ascending line of buckets, is necessary. A skip hoist may be so designed that no ashes come in contact with any of the moving parts. With bucket elevators this is difficult to realize, but not so much so with the gravity type. Skip



COAL STORAGE PLANT OF LEHIGH COAL AND NAVIGATION CO., PHILADELPHIA. TRAVELING CRANE, ELECTRIC HOPPER CARS, AND TRACK TRESTLES OVER BUNKERS. TWO MEN HANDLE 60 TONS PER HOUR. R. H. BEAUMONT CO., PHILADELPHIA

INTERIOR OF BOILER ROOM, CLEVELAND TWIST DRILL CO., SHOWING SIMPLEX VALVE DELIVERING COAL TO AUTOMATIC STOKERS. C. W. HUNT CO., NEW YORK



DOUBLE-POCKET TRAVELING COAL DISTRIBUTOR IN BOILER HOUSE OF UNION MILL, CARNEGIE STEEL CO., PITTSBURG. HEYL & PATTERSON, PITTSBURG, PA.

ELECTRIC TRAVELING COAL ELEVATORS IN BOILER HOUSE OF UNION STEEL CO., DONORA, PA. EACH TRAVELER HAS A CAPACITY OF 60 TONS AN HOUR. HEYL & PATTERSON, PITTSBURG, PA.

hoists are either automatic or non-automatic, and, in the case of the former, are very economical to operate. As bucket elevators are automatic in operation, the labour charge is small; the main items of expense are for power and repairs.

Another method of handling both coal and ashes in the boiler room, and one comparatively recent in application, is the vacuum system. For taking ashes from the furnaces, a suitable pipe system is installed, leading from the ash-pits to a receptacle, where they are wet down before being spouted into cars or other conveyance for removal. Coal may be handled by the same system.

On account of the corrosive action of ashes upon metal, reinforced concrete storage bins are extensively used. These are conveniently built adjacent to or directly over railroad track, where ashes are removed by rail, or on the water front, where boats are used for removal.

Experience with various types of machines and appurtenances for handling coal and ashes in power houses suggest the following items relating to their installation and operation:

Gravity should be made use of where possible, to the exclusion of machinery.

Chutes and hoppers should have slopes steep enough to prevent sticking of materials. For coal, 40 degrees or 45 degrees is sufficient; for ashes, 50 degrees is preferable.

Size of chutes, openings in hoppers for gates or valves, and all areas for passage of materials should be ample, that no clogging of the system may occur.

The space about the machinery, and especially around drives, should be sufficient to allow for passage of attendant and for removal of gears and other parts in case of needed repairs. Owners, or their representatives, are often inclined to install such machinery in a space too contracted for proper supervision.

Transfers should be avoided, if possible.

All parts of a system should be properly protected from the weather by suitable housing or by plenty of grease and paint.

Ashes should be kept from moving parts by guards designed for the purpose. If such precaution is not taken, a rapid destruction of the machinery follows.

Where more than one machine is used for handling coal or ashes, the one having the lowest capacity determines the efficiency of the material-handling part of the power plant. It is better to have all of equal capacity, and this capacity somewhat in excess of normal requirements.

# THE GERMAN IRON AND STEEL INDUSTRY

## ITS DEVELOPMENT CONSIDERED FROM A BRITISH POINT OF VIEW

By T. Good.

The subject of the development of Germany as a manufacturing nation is a matter demanding the closest attention, both from England and from the United States. Mr. Good treats the question wholly from a British view-point, but while his facts and figures are thus drawn from different conditions than those obtaining in America, they may readily be used for comparison with American data, and corresponding lessons drawn. The remarkable growth of the American iron and steel industry is dependent almost entirely upon home consumption, but in the markets of the world the American iron manufacturer will meet the German in an ever-increasing degree, and the figures in Mr. Good's paper are thus of international value and interest.—THE EDITOR.

THERE is no more striking object lesson available in industrial or commercial economics than that afforded by impartial consideration of the progress of Germany's iron industry; and as Germany is Britain's most insistent competitor in the world's iron markets, and as the possibilities of future German competition in iron and steel are provoking much anxious speculation in England just now, we need offer no apology for presenting a brief review of the progress, position and prospects of Germany's iron trade from a purely British standpoint.

Chief among the world's manufactures are now those of iron and steel, so that a nation's industrial welfare may very fairly be measured by its production of pig-iron. In the last twenty-five years or thereabouts the world's *per capita* consumption of iron—its demand for iron and steel goods—has increased by just about 250 per cent. Germany has just about managed to keep pace with that rapidly-growing demand. Our contribution to that great increase has been *nil*. In other words, while the Germans have increased their *per capita* production of iron by 250 per cent., we Britishers have not increased our *per capita* output by a fraction. The following figures are worth notice:

PRODUCTION OF PIG IRON IN MILLIONS OF TONS.

| | The World. | Great Britain. | Germany. |
|---|---|---|---|
| 1880–4 | 20 | 8 | 3 |
| 1885–9 | 25 | 7 | 4 |
| 1890–4 | 28 | 7 | 5 |
| 1895–9 | 36 | 8 | 6 |
| 1899 | 38 | 9 | 8 |
| 1901 | 41 | 8 | 8 |
| 1901 | 40 | 7 | 7 |
| 1902 | 43 | 8 | 8 |
| 1903 | 46 | 8 | 10 |
| 1904 | 44 | 8 | 10 |
| 1905 | 53 | 9 | 10 |
| 1906 | 59 | 10 | 12 |
| 1907 (estimate) | 61 | 11 | 13 |

Between 1897 and 1907 Germany very nearly doubled her production of iron, and increased her exports of iron and steel more than three-fold. Here are the figures relating to Germany's foreign trade in iron:

IRON AND STEEL EXPORTS FROM GERMANY

| | Tons. |
|---|---|
| 1897 | 1,069,000 |
| 1898 | 1,279,000 |
| 1899 | 1,129,000 |
| 1900 | 1,155,000 |
| 1901 | 1,917,000 |
| 1902 | 2,832,000 |
| 1903 | 2,940,000 |
| 1904 | 2,770,000 |
| 1905 | 3,349,000 |
| 1906 | 3,674,000 |
| 1907 | 3,452,000 |

Until recent years most of Germany's iron and steel exports took the form of raw or semi-manufactured material; but now the Germans are very rapidly increasing their exports, not only of more highly finished steel goods, but also of machinery, implements, etc., and are decreasing their exports of pig-iron, billets, etc. The details for the last

two years, excluding machinery, etc., are as follows:

IRON AND STEEL EXPORTS FROM GERMANY.

| | 1906. | 1907. |
|---|---|---|
| | Tons. | Tons. |
| Pig iron | 479,772 | 275,170 |
| Scrap | 136,660 | 120,596 |
| Blooms, billets, etc | 366,359 | 227,332 |
| Joists, tees and angles | 478,049 | 441,032 |
| Wire | 217,418 | 196,581 |
| Railway rails | 369,269 | 417,694 |
| Sleepers and fastenings | 165,047 | 206,940 |
| Railway axles, wheels, etc | 62,985 | 74,788 |
| Bars | 384,240 | 392,148 |
| Wrought tubes | 71,504 | 89,695 |
| Plates and sheets | 267,246 | 268,992 |
| Galvanized wire, etc | 109,943 | 110,959 |
| Wire nails | 67,240 | 69,173 |

That Germany's progress has been substantial is readily admitted; but few acknowledge the difficulties which that country has had to overcome—the incessant war she has had to wage with adverse natural and economic circumstances—in the attainment of her present position as the world's second iron country. While Germany has taken up this position Britain has been relegated from the first to the third position as an iron country in point of production, and, unless we are careful, the Germans will soon dislodge us from the premier position in the matter of exportation, for they are gradually overtaking us in exports, just as they have already beaten us in output. And the Germans have made, and are now making, this great progress against huge odds. In whatever respect Britain may yet find, or imagine, herself ahead of the Germans, she would do well to remember that, in the modern race, she had a long start of our contemporaries, and enjoyed—at any rate, possessed—far better opportunities of attaining and retaining supremacy than her rivals.

A generation ago we were leagues ahead of Germany in the manufacture and exportation of all kinds of iron and steel. To-day Germany is our most formidable rival. In her rapid industrial development Germany has enjoyed no special favours in natural resources or in geographical situation, yet she has made greater headway than we have done. The great progress of the United States is frequently attributed to superior natural resources, but superior resources cannot be urged in explanation of Germany's progress. In every fundamental we hold the advantage of Germany. Starting on her modern career heavily handicapped, Germany's industrial attainments are monuments to the efficiency of her craftsmanship and the diligence of her enterprise. Her minerals were mostly of low grade and inconveniently deposited. For example, while in Britain we have coal and iron ore practically in the same beds, and within the easiest possible distance of good, natural harbours, in Germany most of the iron ore is deposited far from the coal, and both ore and coal—and, therefore, furnaces—are at great distances from the shipping ports. Her minerals are no better, but slightly inferior to ours. Her iron ore is mined somewhat more cheaply than ours; but her coal costs more, while charges for assemblage of material at furnaces are much heavier in Germany than in Great Britain. Germany's ton-mile railway rates are little more than half as high as ours, it is true; but that advantage is more than neutralized by long haulage distances. The average haul for iron-making materials is somewhat about 150 miles in Germany, against an average of less than 30 miles in this country. Mr. J. Stephen Jeans, in his "Iron Trade of Great Britain" (Methuen, London), gives us the following figures relating to cost of transit:

APPROXIMATE FREIGHT RATES PER TON OF COAL OR COKE, FROM MINES OR OVENS.

| | *s d* | | *s d* |
|---|---|---|---|
| Great Britain: | | | |
| Cleveland | 2.0 | to | 3.0 |
| Cumberland | 7.0 | " | 7.6 |
| South Wales | 1.0 | " | 1.6 |
| Scotland | 1.0 | " | 1.6 |
| Lincolnshire | 4.0 | " | 5.0 |
| Northamptonshire | 5.0 | " | 6.0 |
| South Staffordshire | 1.0 | " | 1.6 |
| Germany: | | | |
| Westphalia | 1.6 | " | 2.0 |
| Lorraine | 6.0 | " | 7.0 |
| Luxembourg | 6.0 | " | 7.0 |

For carrying iron ore to furnaces it costs in few cases more than 1*s* 6*d* per ton in Britain, against an average of more than 6*s* per ton in Germany.

Such are the natural conditions in Germany that, notwithstanding the fact that our rivals are more up to date in the matter of blast-furnace practice than we are, the annual output per furnace being 40,000 tons of pig-iron in Germany against 27,000 tons in this country, they cannot produce a ton of pig-iron as cheaply as we can. The fundamental and cardinal point in the problem of successful iron and steel manufacture and sale is the price of pig-iron. That country which gets its pig-iron the cheapest ought to have nothing to fear from its rivals. Here are some interesting figures:

PRICES OF PIG-IRON IN FIVE YEARS, 1900-1904, COVERING A "BOOM" AND A DEPRESSION.

| | Germany. No. 1 Foundry. | Great Britain. Scotch Warrants. |
|---|---|---|
| | *s d* | *s d* |
| 1900 | 96.0 per ton. | 69.4 per ton. |
| 1901 | 102.0 " | 53.9 " |
| 1902 | 65.0 " | 54.6 " |
| 1903 | 63.6 " | 52.3 " |
| 1904 | 60.4 " | 51.5 " |

Here we find that the price of pig-iron, the foundation of the steel and engineering trades, averaged, in a period of five years, 77*s* 4*d* per ton in Germany, against 53*s* 3*d* in Britain. Yet we Britishers frequently allow the Germans to beat us, and are continually afraid of German competition! Here are some more recent figures:

PRICES OF PIG-IRON.

| | Germany. No. 1 Foundry. | Great Britain. Scotch Warrants. |
|---|---|---|
| | *s d* | *s d* |
| January, 1906 | 73.0 per ton. | 58.5 per ton. |
| January, 1907 | 85.0 " | 65.8 " |
| December, 1907 | 85.0 " | 58.7 " |
| Fixed for first half of 1908 | 79.0 " | |

Not only does it cost Germany more to assemble her raw materials at furnaces—which means a higher price for her pig-iron and steel—than it costs us, but when the furnaces and mills turn out their finished products, these products, if for export, must be conveyed a much longer distance to a port of shipment in Germany than in Great Britain. Besides, modern Germany had to fight her way into the markets of the world, markets which had long been occupied and crowded by ourselves. Such are a few of the disadvantages under which our competitors have laboured. We Britishers attained our supremacy when we had no formidable rivals; the Germans have taken up their position in face of the keenest competitors.

Germany's progress is often put down to cheap labour. However true that contention may be in the case of a few minor industries, it does not hold good (so far as competition with England is concerned) in reference to the iron, steel and kindred trades. In 1895 representatives of the British iron trade, upon their return from a visit to the leading iron and steel works in Germany, expressed their surprise at finding how very nearly the wages paid in that country were to those prevailing here. In not a few cases the wages for the same classes of work were "on all-fours" declared the secretary. That was more than twelve years ago, since which the increase of wages has been considerably larger in Germany than in Britain, particularly in the case of unskilled labour. Within the last thirteen years the wages of shipbuilders (skilled men) have increased by 22 per cent.; of engineers' fitters, machinists, etc., by 35 per cent.; of general labourers in iron, steel and engineering works by 50 per cent., and of miners by 50 per cent. In reference to miners' wages it may be mentioned that the average wage of the German miner is not so much below the wage of the British miner as is the *per capita* output of coal in Germany below that of this country. Apart from some branches of shipbuilding, it is questionable whether the wages now paid in the German iron and steel industry are anything below those of Britain. The wages paid in some of the leading German iron works appear, from wage-book figures before us, to be quite as high as those paid in similar works of this country; while the upward tendency is certainly more pronounced there than here. Then, again, labour dis-

putes have been much more frequent, and their resultant effects more acute in Germany than in Britain in recent years.

Broadly and generally speaking, it is not inaccurate to say that, in climate, in natural resources, in convenient supplies of coal and ore, in geographical situation and in labour conditions (in point of efficiency, if not cost also) as an iron and steel-producing country, and particularly as an exporting country, we hold some marked advantages over Germany. There is certainly nothing of a fundamental character to enable that country to beat us, and whenever and wherever the Germans have succeeded in underselling us, in neutral or in our own markets, their success has been due, primarily if not entirely, to more careful technical training, more diligent attention to business opportunities, and a more highly organized system of sales than have yet been adopted by ourselves. German success has not been due to any monopoly of Nature's bounties or human skill, but to efficient organization—not to better opportunities, but to better grasp of opportunities. Frequently German success has been purchased at a price, and in a manner alien to British ideas; but the success, upon the whole, has been sufficiently substantial to cause uneasiness in this country. How has that success been effected, and what is likely to be the measure of German success in competition with Great Britain in the future?

The chief factor in the promotion of Germany's foreign trade these last ten years has been the policy of granting co-operative bounties on steel goods for export, and now that this policy, after temporary suspension, is being revived by our German rivals, the moment is opportune to refer in some detail to this system of fostering export trade. These export bounties on German steel and steel goods, machinery, etc., have very materially affected British trade. For all practical purposes they were inoperative from the middle of 1906 to the end of 1907; but now that Germany's home demands have slackened, they are being reintroduced, and may possibly have a detrimental effect upon our trade. However, the system is well worth special attention just now. In the past, German competition would not have been a very serious affair but for these bounties; and if, in the future, German competition is of a disturbing character, it will be due to this same bounty system.

In order to understand how these bounties are manipulated, it is necessary to note that industrial syndication is more complete and more effective in the iron, steel and engineering trades of Germany than in any group of industries in any other country—not even excepting America. The production, distribution and price of practically every material and article of iron and steel manufacture in Germany, from coal and iron ore to sewing machines and wire, are regulated by a syndicate or manufacturers' union. About eleven years ago there were ninety syndicates in the German coal and iron trades. Owing to absorption consequent upon improved organization, there are now about half that number. There are separate syndicates governing coal, coke, lignite, briquettes and iron ore, pig-iron, iron and steel castings and foundry products; tubes, rails, rods and girders; plates and sheets; there are unions of electrical works, of sewing-machine makers and of nail manufacturers, etc. Besides syndicates for various products, there are in some cases district syndicates where local conditions are of a special character. But these local, special or sectional syndicates are usually united with kindred syndicates, or work in remarkable harmony with one another, considering the frequent conflict of interests. For example, while for one special article there are four separate district syndicates enjoying local autonomy, there is a central, or national syndicate, governing

the district unions in the interests of the whole trade. And in all but supreme authority there is the famous steel syndicate of *Stahlwerksverband*, controlling practically all the important concerns in the country.

These syndicates are typical of the military character of German institutions in general. The usual system is for a number of experts to visit each of the associated works and ascertain its capacity of production and aptitude for any special class of work. Then orders, which are usually received by the central offices, are allocated to the various establishments forming the syndicate, regard being paid to the situation and circumstances of the several firms, in order to avoid waste and overlapping in production and unnecessary delay or cost in transit. Generally speaking, a Russian or Austrian order would go to Silesia, while a French or English one would go to Westphalia. And not only are prices fixed and orders allotted by syndicate agreement, but payments usually pass through the central offices. Moreover, the syndicates usually arrange times, methods and costs of transit and delivery, and attend to many other matters with the greatest possible advantage to their constituents; for their expert officials are better informed than any private manufacturer immersed in the technicalities of his own particular works can hope to be. While different syndicates have different rules (some allowing their members more liberty of action than others), these may fairly be taken as the general outlines of the management of German coal and iron syndicates.

It was in 1897 that several of the sectional syndicates inaugurated the export bounty policy in the steel trade. The coal, coke, pig-iron and other syndicates controlling raw or partly manufactured materials agreed to supply their associated customers—the rolling mills, steel manufacturers and engineers—with coal, iron, steel ingots, etc., at cheaper rates when such materials were needed for manufacturing goods for export than when required for manufactures for the home market. From time to time the bounty rates, or differences between home and export prices, were increased or decreased in response to the fall or rise in the domestic demand, the primary object being to effect full employment for the works. Through the operation of these bounties German steel, steel goods and machinery have been sold in British markets cheaper than in Germany, and at prices considerably below the natural cost of production. These bounties have sometimes represented rebates on standard "home" prices of 1*s* 6*d* per ton of coal used in manufacturing for export, 4*s* 10*d* per ton of pig-iron, 15*s* per ton of blooms, billets, etc., and 20*s* per ton of shapes. From these figures it can easily be seen that any highly-finished German product for export was subsidized to a very considerable extent.

How far the policy was successful may be judged from the fact that, in the nine years—1897-1905—in which the bounties were in active operation, German iron and steel exports increased by more than 200 per cent., while British exports only increased by about 10 per cent. During the "boom" of 1906-7, however, Germany's home demand was so good that the need for export bounties and "dumping" practically ceased. The bounties were first reduced and then suspended. Now that Germany's home demand has diminished, the bounties have been reintroduced. In what position is Great Britain to withstand another spell of keen German competition fostered by export bounties? Will Germany be able to make as much headway in the next ten years as she made in the last ten?

Before we venture to answer those questions, let us take another glance backward, so that we may better appreciate the changed conditions now in existence—the new conditions,

which will modify, if not absolutely govern, the future. We may say, shortly, that just as Germany's great progress has been due to organization, and not to any natural advantage, so has our comparative lack of progress been due to lack of organization, and not to any natural disadvantage. Without her vast system of industrial syndication, with its military-like discipline, and the artificial fostering of foreign trade by co-operative export bounties, Germany could not have attained her present status in the world's iron markets. And but for the fact that we Britishers have lacked organization—have failed to meet our organized competitors with organized resistance—we need never have been undersold by the Germans, and need never have been afraid of German competition.

This German system, like the American "trust" system, has its limitations; with these we are not now concerned; our point is that a nation, or an industry, with organization and determination, can achieve great success, even in the face of great natural and geographical difficulties, while its contemporaries, with fewer and smaller difficulties, but lacking in organization, make little headway. If the Germans have so rapidly increased their production and exportation of iron and steel goods in recent years, and provided so much employment for their own capital and their own labour in their own country, why have we, who have much cheaper iron at command, failed to make similar progress? Simply because we have neglected to take the fullest advantage of our opportunities, and have been wanting in that patriotic and enthusiastic faith in our own abilities, powers, resources and destiny which we find so abundant and super-abundant in other countries. We modern Britishers have for more than a generation permitted ourselves to be afraid of, if not to be beaten by, competitors less powerful and less advantageously situated.

But we are about to alter all that! The British iron and steel industry has just recently taken a new lease of life, and the future will see us making greater and our rivals less progress relatively than has been the case these last ten or twenty years. The world's iron trade will increase, and we shall get a fair share of it. We are improving our manufacturing processes and organizing our industrial and commercial forces. Hitherto our chief danger in the matter of German—and also American—competition has lain in the circumstance that such competition has been directed by powerful trusts and syndicates, while the opposition we have been able to offer has been that of individual firms. But we are remedying that weakness. Our manufacturers are combining for self-defense, and if our rivals "dump" their goods upon our markets below profitable cost of production, we, too, shall adopt the policy of selling cheaper abroad than at home. So long as we are able to mine coal, smelt iron, make steel and put the finished product on board ship at a cost—at a natural and profitable cost—below that at which Germany can, we need not fear German competition, if only we organize our forces intelligently.

# TALL-BUILDING CONSTRUCTION IN NEW YORK

By C. H. Hughes

IN the development of every city certain localities, owing to their natural advantages, are more valuable than others for the transaction of special lines of business. With this uniting of business interests buildings which were at one time ample in size have become inadequate for the up-to-date business man. To meet this growing demand for better facilities and concentration in business the modern sky-scrapers have been developed. Their present perfected development has been due to the careful investigation of stresses and strains in frame structures and to the rapid advancement made in the manufacture of steel. In fact, the modern sky-scraper has broken all previous records and traditions of architecture and building construction.

### FOUNDATIONS

No matter how carefully the column loads and wind reactions have been calculated or how beautifully the interior is decorated, if the foundations are not properly designed and well-built the building will be a failure. It soon became evident that the sky-scraper, with its tremendous weight, could not be built on pile foundations, such as had been previously used for buildings eight and ten stories high; but a new type of foundation was necessary, one that would anchor it to solid rock. This has led to the developing of the pneumatic-caisson system for foundations.

A caisson is a box about 10 feet wide by 12 feet long (the size depending on the column load it is to carry), usually built of 3-inch planking, braced with angle irons, and is generally composed of three sections, the first containing the working chamber, called the working chamber section, and other sections, which are alike called cofferdams. In the first section, about 6 feet from the bottom or cutting edge, a concrete roof is built, which extends to within a few inches of the top. The cutting edge consists of steel plates ⅜ of an inch thick bolted to the wood planking and reinforced by a $3 \times 3 \times 7.2$-pound angle. The cutting edge cuts into the earth as the caisson is sunk. Embedded in the concrete roof is a steel shaft 3 feet in diameter, and to the shaft is bolted the air-lock, through which the men and the material pass. In ordinary earth it is possible to take out thirty or forty buckets in an hour; but when hardpan or rock is encountered, the excavation is much slower, and perhaps not more than four or five buckets can be taken out. Compressed air is turned into the working chamber when water starts coming in below the cutting edge. As the excavation progresses, and as the caisson continues to sink, the pressure of the air must be continually increased, to keep the water out. For the first few feet of sinking the air pressure is not more than 4 or 5 pounds per square inch, but after the caisson has sunk 40 or 50 feet the pressure is increased to 25 or 30 pounds. The first section is sunk until the top is only a few inches above the ground, and then a cofferdam is bolted to it. A cofferdam is generally built of 3-inch planking, braced with angle irons, and of the same width and length as the first section, only it has no working

chamber. Before it is placed on top of the first section the air-lock must be removed and a door closed in the bottom of the shaft, to keep the air in the working chamber. When the cofferdam is in position, another length of steel shaft is added to that in the first section, and to this piece of shaft is bolted the air-lock. Concrete is next dumped around the shaft to within a few inches of the top of the cofferdam. Cofferdams are added and the sinking continued until rock has been reached, when the working chamber and the shafts are filled with concrete and the air-lock is removed. The caisson is now completed, and is ready to have placed on it the cast-iron or steel base of the building column.

In Chicago pneumatic caissons could not be used for foundations, as solid rock was such a distance below the street level that it was impracticable to reach it. So the buildings were actually floated in the earth, by spreading the bases of the columns to cover such an area that the load per unit of area should be the same for all the columns, and that it should not exceed 3,000 pounds per square foot. The buildings generally settle 2 or 3 inches, and sometimes more; but this is of minor importance, provided it is uniform at all points.

### COLUMNS

There are two classes of steel construction for sky-scrapers, viz., the cage and the skeleton. In the cage construction the frame is strengthened for wind stresses, and the walls act as curtains. In the skeleton construction the frame carries only the vertical loads, and depends upon the walls for its wind bracing. Either steel or cast-iron columns are used for the frame.

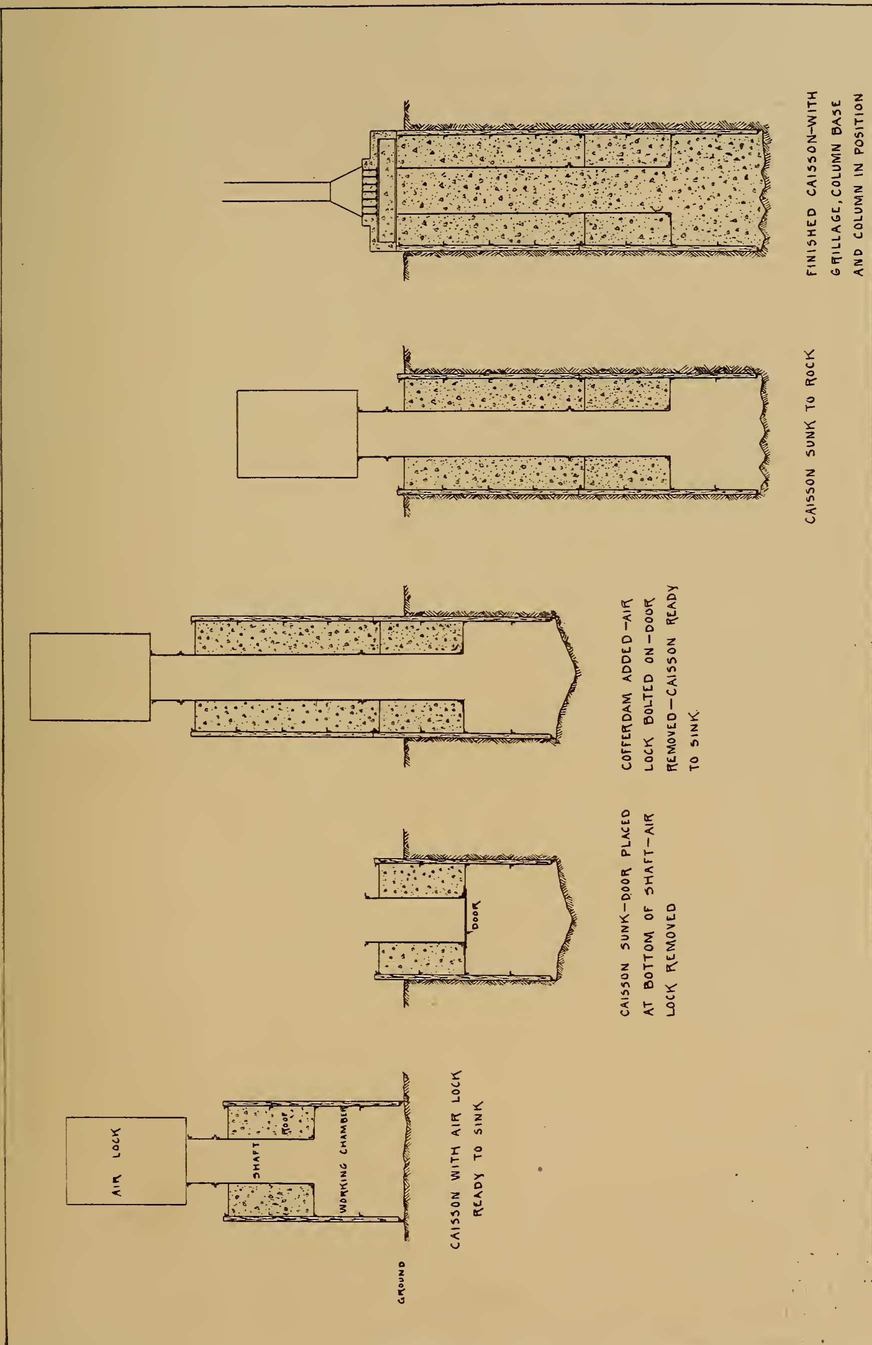
Steel columns are built up of plates and angles, rivetted together, and extend from the foundation to the top of the building. With a careful study of the loads, wind stresses and strength of the materials, it is possible to erect buildings fifty or sixty stories high, and, from an engineering standpoint, there is apparently no limit to their height, yet from a financial one there is. It has been found that the economical height (towers such as those on the Singer Building and the Metropolitan Life Insurance Building excepted, which are more or less of an advertisement of the main building) is about twenty-six stories. The economical height is based on the ratio of the office rent per floor, to the increased cost of the columns and other structural parts due to the excessive height.

Cast-iron columns (either circular or square in cross section), which are bolted together and extend from floor to floor, are used in the cheaper class of buildings. With these columns the building is not so rigidly connected as with the continuous steel columns. On account of this lack of rigidity in the connections, a certain building in New York was actually forced several inches out of plumb by the wind. It is not practicable to erect extremely high buildings using cast-iron columns, and perhaps the limit is twelve or fourteen stories.

### WALLS

Architects are limited in their treatment of the sky-scraper from an artistic point of view, on account of its extreme height in proportion to its width. In many ways the sky-scraper may be called a "misfit," for on the outside of the steel frame are put materials, as brick and stone, which have entirely different physical properties, not only in regard to strength, but also having co-efficients of expansion and contraction.

The outside walls vary in thickness with the height of the building, and according as it is of cage or skeleton construction. If it is of cage construction, the walls act only as curtains, and are thinner than in the case of skeleton construction; for in this latter case it is necessary for them to resist the wind pressure un-




PNEUMATIC-CAISSON SYSTEM FOR FOUNDATIONS OF TALL BUILDINGS

supported by the steel frame. If hollow walls are employed, the same quantity of stone, brick or cement should be used as if they were solid. The inside 4 inches of a wall can be built of hard-burnt, hollow brick, well tied and braced together, or of terra-cotta blocks.

### FLOORS

To the steel or cast-iron columns are fastened I-beams supporting the floors, which, in sky-scrapers, are designed for live loads of 50 to 70 pounds per square foot. The floors are built either of terra-cotta blocks or of concrete reinforced with wire cloth or expanded metal.

Terra-cotta blocks are made of good refractory clay, and are termed dense, semi-porous or porous. The porosity is obtained by mixing sawdust with the clay and burning it, the sawdust disappearing and leaving small spaces in the clay. Porous terra cotta can resist fire and water better than either the dense or semi-porous, but it is not so strong. For ordinary floors the semi-porous blocks are used, and over them is spread a thin layer of concrete, which, in turn, is often covered with a wooden floor. The blocks are adapted for flat or for arched floors. When strength is required and a flat ceiling is not necessary, arched floors should be used, particularly for warehouses, lofts and factories, where heavy loads are to be carried. Even with this construction, if a flat ceiling is desired, it is a comparatively easy matter to fasten metal lath below the bottom of the floor beams. Some of the advantages of terra-cotta blocks are: they are absolutely fireproof, they weigh less per cubic foot than any other kind of fireproof flooring, and they are nearly soundproof.

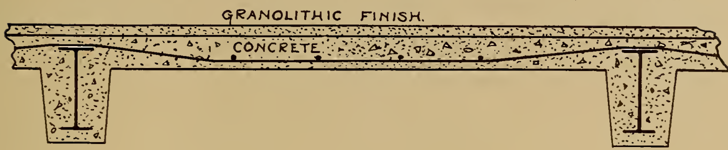
Reinforced concrete makes an excellent floor, and is well suited for carrying loads of 150 to 200 pounds per square foot. There are varieties of reinforcement used, each manufacturer claiming advantages of his over all others. The Brownhoist Company manufactures thin, grooved iron sheets (trade name Ferroinclave), which is a good reinforcement. The sheets are bent in the form of an arch, and extend from beam to beam. Concrete is dumped on top, and on the under side grout is worked into the grooves with a trowel. This makes a very cheap and easy floor to erect, as no concrete forms are needed. Wire-cloth (consisting of steel wires laid in squares and electrically welded together) and expanded metal are also extensively used. Concrete forms are placed below the floor beams, the wire-cloth or expanded metal bent over the beams and fastened to them, and then they are covered with concrete. When the concrete becomes hard the forms are removed and the surface smoothed off.

### MECHANICAL EQUIPMENT

The modern sky-scraper has a very elaborate mechanical equipment. The electric lighting outfit in many of them is large enough to light a small town; for instance, the new Singer Building has nearly 15,000 incandescent lamps. As space in the basement is always limited, direct-connected engines and dynamos are generally installed instead of belt-connected, and the boilers are operated under a high steam pressure. The boilers, besides delivering steam to the engines, also supply it to a variety of auxiliary pumps, as boiler-feed, fire pump, blow-off tank pump, and pump for forcing water through the building.

Steam or hot-water heating is used, and the sizes of the radiators are proportioned to give an average temperature of 65 degrees F. in any room when the temperature outside is zero. Hot-water heating is generally preferable to steam, as it gives a much steadier heat. The up-to-date systems have automatic regulating devices attached to the radiators, so if the temperature rises or falls below a certain point the steam or hot water

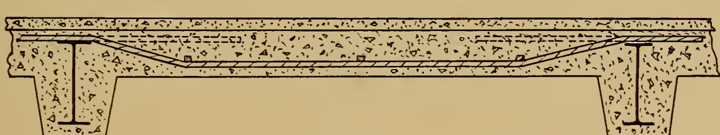
CLINTON WIRE CLOTH
[SMALL STEEL RODS WELDED TOGETHER FORMING SQUARES]



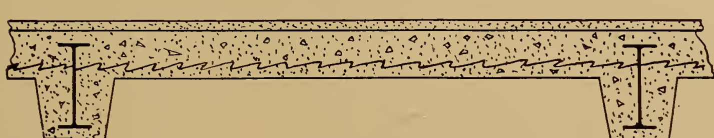

FERRO-IN-CLAVE.
[CORRUGATED STEEL SHEETS.]


TERRA-COTTA BLOCKS.

TWISTED OR CORRUGATED RODS.



EXPANDED METAL.



SYSTEMS OF FIRE-PROOF FLOORING

is automatically turned on or off. Some buildings are heated by the exhaust steam from the engines, but many have boilers especially devoted to the heating.

Mechanical systems of ventilation are complicated, costly to install, and seldom come up to expectations. In many cases the ventilation can be sufficiently provided for by small ventilators in the window sashes, or by openings placed below the radiators communicating with the outer air.

The arrangement of the sanitary system is important. The supplying of water for wash-stands, the disposing of wastes and the flushing of lavatories compels the use of the best materials, with careful installation. An idea of the amount of material required can be obtained from the Singer Building, where 600 lavatories and 74 toilets were installed. The lavatories and toilets in some buildings are placed only on two or three floors; but while this arrangement may have advantages, from the owner's point of view, yet it has many disadvantages from the tenants'.

Sky-scrapers are equipped with both express and local elevators. The express elevators do not stop until the tenth floor is reached, and run at a speed of about 600 feet per minute, while the local elevators go only to the tenth floor and stop at all the floors. There are two types of elevators in general use, one lifting the car by cables from the top, and the other with a hydraulic plunger acting directly upon the bottom of the car. The former are operated either by electric motors or hydraulic cylinders and the latter by hydraulic rams, the cylinders extending the full height of the building into the ground.

No modern office building is complete without a vacuum cleaning system. To describe it briefly, there is a vacuum pump (driven by an electric motor, gas or steam engine), which draws the dirt through a hose into large waste tanks in the basement. With this system, which has been developed by the Vacuum Cleaning Company of New York, it is possible to clean carpets and draperies in a room thoroughly without removing them.

### FIRE PROTECTION

In designing buildings, particularly sky-scrapers, care should be taken to limit the number of open stair-wells and elevator shafts, thus preventing draughts, which tend to draw the fire, when once started, from one floor to another. In a recent fire—in the Parker Building, in New York City—which was of fireproof steel construction, the stairways and elevators were so arranged that nothing could stop the fire from spreading from floor to floor, and all the efforts of the firemen were of no avail in trying to save the contents of the building.

A study should be made of the materials used in building construction. Steel columns will not burn; but if they are left exposed in a fire they will bend, and will, perhaps, collapse. Cast-iron columns, when subjected to intense heat and have water played on them, will crack. Stone and slate will not burn, yet they will crack and splinter if water comes in contact with them while they are hot. Terra-cotta blocks will stand a high temperature without giving way, but if they are confined too closely by the floor beams they may fail by expansion. Concrete and ordinary bricks are not materially affected by heat.

It is of vital importance to have the steel or cast-iron columns protected with a fireproof covering. As both terra cotta and concrete resist heat, either will answer the purpose. When terra-cotta blocks are used, they should be at least 2 inches thick, with an air space running through them. An alternate method is to encase each column in a light cast-iron shell, with a 2 or 3-inch air space between it and the column, or fill the space with

FULLER BUILDING, MADISON SQUARE NEW YORK

an incombustible, non-conducting material. Instead of the light casing, expanded metal completely surrounding the column and covered with two rough coats and one finished coat of hard plaster makes a good protection.

The floor beams should be entirely covered with terra-cotta blocks or concrete, so that no part of them is left exposed. It is almost as important to have the floor-beams well protected as the columns.

A building may be constructed with fireproof columns and floors, yet with wooden office trimmings, window casings, door frames, doors, etc., as well as the combustible contents of desks and filing cases, it is nearly impossible to prevent them from burning after they have been dried out by the steam heat. The heat from such a fire may be sufficient to cause the columns and floors to wilt and ultimately to collapse. The substitution of metal office trimmings, desks and filing cases may do much towards decreasing this fire risk.

Defective electric wiring and faulty installation of dynamos, motors and other electrical apparatus form frequent causes of fires. Special attention should be paid to the mechanical execution of electrical wiring, and none but first-class men, using the best wire and insulators, should be employed. In laying out an installation, the distribution centers should be located in easily accessible places, and the load should be evenly divided among the different branches of the system.

Several wrought-iron stand pipes, extending from the basement to the roof, with fittings and connections to stand a pressure of at least 300 pounds per square inch, should be installed. The stand pipes should be placed in fireproof stairway-enclosures where practicable, or near stairways when they are not so enclosed. Hose connections, with linen or cotton, rubber-lined hose long enough to reach any part of the floor, should be stowed in racks near the stand pipes, which must also be provided with Siamese steamer connections on the outside of the building, placed about a foot above the curb.

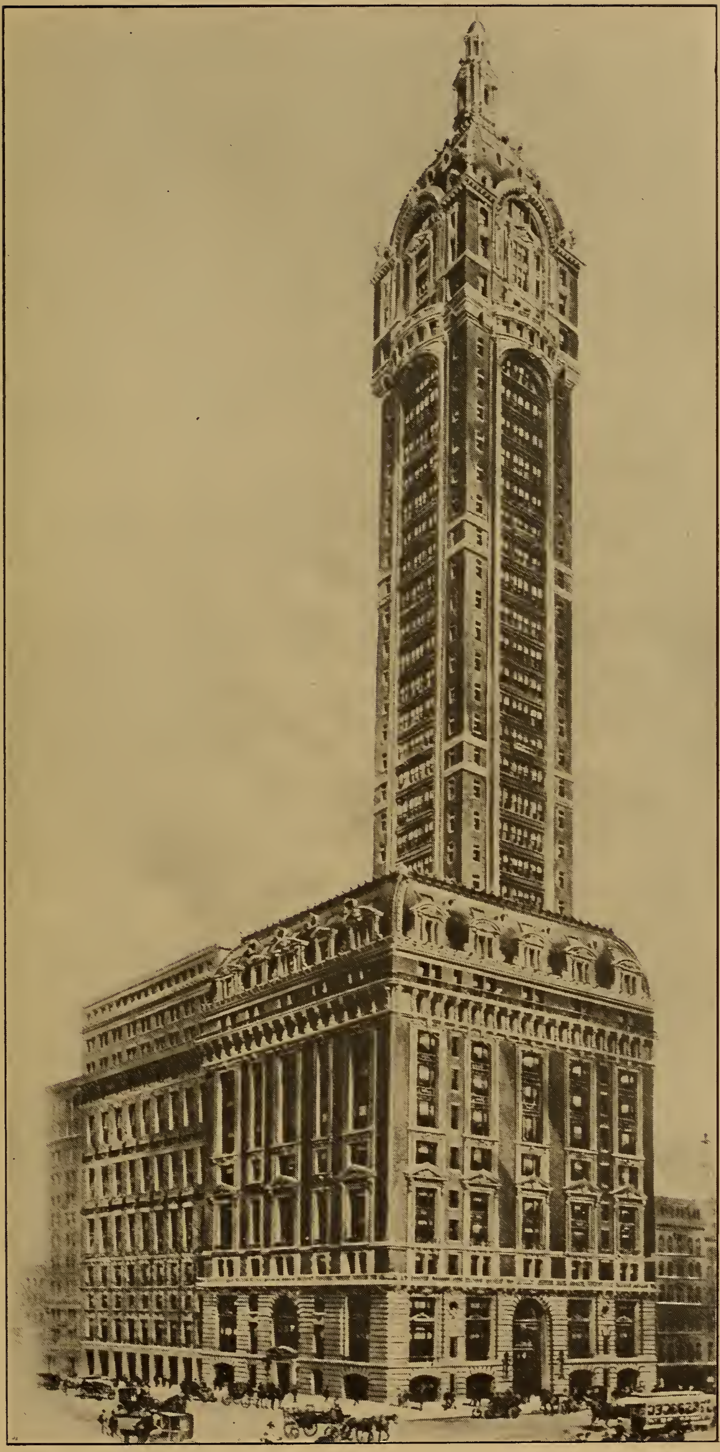
Thermostats or automatic fire-alarm systems should be in every office building. With this system notification of fire will be at once sent to the central station and from there to the fire department.

The results of the Baltimore, Rochester and San Francisco fires showed that walls built of stone did not resist the fire so well as those of brick, and, in general, the columns and floors that were encased in fireproof material were little injured. Reinforced concrete buildings, with concrete floors, columns and walls, were not seriously affected. This was doubtless due to the fact that the concrete was able to stand excessive heat, and that the steel reinforcement was so thoroughly embedded in the concrete that the heat from the fire did not have a chance to reach it.

### LIFE OF SKY-SCRAPERS

The rusting of steel or cast-iron columns cannot be prevented, and upon the rapidity of this oxidation the life of the building depends. The bases on which the columns rest and the columns themselves should have all mill-scale, rust and dirt removed by a wire brush or by a sandblast. The wall columns should then be enclosed in metal lath covered with concrete for their entire height, while the interior columns should be protected in the same way up to the first floor, and from there up be painted with at least three good coats of anti-rust paint before any fireproof covering is placed around them.

Brick, stone and concrete last longer than the buildings of which they are component parts, for the average office building becomes obsolete in twenty-five or thirty years, and is replaced by another more modern one. For example, the old Coal and Iron Exchange Building, corner of Church and Cortlandt streets, in New York, was recently



SINGER BUILDING AND TOWER, BROADWAY AND LIBERTY STREET, NEW YORK

torn down and the City Investing Building erected in its stead. The brick and stone walls and the concrete foundations were found to be in first-class condition, and would have been good for many years of service.

The same materials are used in sky-scrapers as were used in the old buildings, with the exception of the substitution of steel and cast-iron columns for brick. If the columns are well protected, there is every reason to believe that sky-scrapers will last indefinitely, or until they are, in turn, superseded by some other class of office buildings.

### SOME NEW YORK SKY-SCRAPERS

The Hudson Terminal Buildings, situated on Fulton, Dey, Cortlandt and Church streets, have many interesting engineering features. Caissons, forming a solid wall 9 feet wide, were sunk to rock around the entire area and the interior excavated to a depth of about 40 feet below the curb level. By reason of the limitation of the walls to 9 feet in thickness, extra heavy girders were necessary in the two lower floors, to assist the walls in resisting the lateral pressure of the earth. Tunnel caissons were sunk in Cortlandt and Fulton streets alongside of the wall caissons, and at present openings are being cut in the latter for the trains, which will eventually run under both streets and through the Terminal Buildings. There are 175 columns, 25 of which rest on the wall caissons and the balance on separate circular caissons varying in diameter from 7 to 14 feet. Special column-spacing was required in order to avoid interference with the track layout. The lower two floors are built exceptionally strong, with large girders and concrete reinforced with sheets of Ferroinclave, while the other floors are of terra-cotta construction covered with a thin layer of concrete. In the basement will be the usual mechanical equipment, and also a sub-station, which is a part of the electric system supplying current for the tunnel trains.

The new Singer Building, corner of Broadway and Liberty street, is a remodeling of the old Singer and Bourne Buildings, with the erection of a 63-foot by 63-foot tower. The new building, including the old buildings and the tower, has a cubical contents of 66,950,000 cubic feet and a floor area of 411,000 square feet, or nearly 9.5 acres. The question of wind bracing for the tower was an important one, and was provided for by a system of diagonal tie rods in the vertical panels between the floor beams and the columns. The columns were spaced 12 feet apart and connected with each other by 12-inch I-beams, reinforced by channels, where they serve as wind-bracing in addition to carrying the floor. The total weight of the tower is about 18,300 tons; but yet so great is the wind pressure during a storm that it actually has a tendency to lift, and, to prevent this, the columns are securely bolted to caissons, which have been sunk to rock, a distance of more than 80 feet below the curb. The entire building is designed to be absolutely fireproof, the steel work is protected by fireproof material, and no wood is used in the office, it being entirely replaced by metal. The usual stand pipes and hose reels are installed, besides fire pumps with a capacity of 120,000 gallons per hour. The following data are interesting:

| | |
|---|---|
| Height from basement floor to top of flagstaff | 742 feet |
| Weight of steel in entire building | 9,200 tons |
| Number of stories | 49 |
| Highest office story | 38 |
| Number of elevators | 16 |
| Number of steam engines | 5 |
| Number of dynamos | 5 |
| Number of boilers | 5 |
| Number of steam pumps | 28 |
| Length of steam and water-piping | 15 miles |

The first section of the Metropolitan Life Insurance Building, now occupying the block from Twenty-third to Twenty-fourth streets and from Madison to Fourth Avenue, was completed in 1894. New sections were added in 1898, 1901, and in 1905 the land occupied by Dr. Parkhurst's church was secured. A year later the church was torn down, and preparations were made for erecting

METROPOLITAN LIFE INSURANCE BUILDING, MADISON SQUARE, NEW YORK

a mammoth tower. This tower is quite different from the one on the Singer Building. It has twelve wall and eight interior columns, connected at every fourth floor by diagonal braces riveted to the top flanges of the floor beams, which will prevent transverse distortion. The columns are built up of 8-inch angles and heavy web and cover plates riveted together, making a total weight of nearly 1,800 pounds per linear foot. They will be supported on I-beam grillages, with concrete footings resting on solid rock about 20 feet below the curb. The wind pressure, if calculated at the usual 30 pounds per square foot, is enormous, and is taken care of by deep wall girders and knee braces, which transfer the strain to the columns and the foundation. The average cross section of the tower is 75 feet by 85 feet, and the height from the sidewalk to the top 700 feet. There are fifty stories above the sidewalk and two below. The total cubical contents of the building, including the tower, is 16,237,000 cubic feet, and the floor area 1,080,000 square feet, or about 25 acres.

The City Investing Building extends from Broadway to Church street on Cortlandt street, except for the building on the corner of Broadway and Cortlandt street. It is 486 feet high from the curb, and has thirty-two stories, with a total area of 500,000 square feet, or 11.4 acres, and a cubical contents of 10,300,000 cubic feet. The estimated weight, exclusive of the live load, is 86,000 tons. There are ninety columns, carrying a maximum load of 1,700 tons per column, supported on rectangular caissons.

# POWER TRANSMISSION

## A COMPARATIVE STUDY OF THE MERITS OF GAS AND ELECTRICITY.

By Professor C. A. Smith, B. Sc.

Until recently it seems to have been assumed that the advantages of electricity over all other methods for the transmission of power were so great that no other method need be considered. The development of gas-power, however, has brought the possibilities of gas transmission into the field, and when the practicability of its use in connection with power development at the coal mines is considered, its merits demand just such a study as has been given by Professor Smith. Although the data and computations are based upon British conditions, the principles hold good for other parts of the world, and may form a foundation for similar studies wherever power is generated from fuel.—THE EDITOR.

PROBLEMS of power transmission have always presented attractive features to engineers. During the past decade the transmission of power by means of electricity has been considered to be the most economical and efficient system. The central generating station, with the complex system of transformers, high-tension cables, sub-stations, rotary converters, etc., has been rendered reliable by an infinite amount of patience and ingenuity. Much as we admire these things, we must not lose sight of the fact that all the electric power transmission schemes involve a great amount of expense and a considerable loss of power. Despite the triumphs of the steam turbine, the boiler and any form of steam engine remains, comparatively speaking, an inefficient combination. In a large number of power stations the combined efficiency of the boiler and the engines does not exceed 12 per cent. We may, therefore, be excused for examining any new suggestion which may be made on the subject of power transmission in order to see whether there is not some more economical method. The reader must at once free his mind from bias. The use and flexibility of the electric motor has nothing whatever to do with the problems of power transmission for long distances. In the suggestion set forth in this article it is assumed that, finally, the power is converted into electricity, for there is no challenge that electricity is the best agent for power distribution. It may be that we shall live to see it replaced for transmission purposes by power-gas.

### GAS-ENGINE SUB-STATIONS

Owing to the advent of power-gas and to the vast improvements effected in large gas engines, it is probable that in the future considerable attention will be paid to the transmission of power by producer-gas. Briefly, the method consists of setting up a large producer-gas plant at some convenient centre and distributing the gas to the sub-stations by means of suitable piping, where electricity would be generated through the medium of gas engines. This is quite possible, as gas engines up to 1,000 brake-horse-power are quite reliable; in fact, Continental manufacturers guarantee their engines up to 2,500 brake-horse-power. No engineer would hesitate to use this type of engine from a theoretically efficient point of view, as the thermal efficiency easily reaches 25 per cent.

Besides the electricity generated at the sub-station, a supply of power-gas could be piped to the various private consumers for heating and cooking purposes.

Compressors, to give the gas suffi-

cient initial velocity, would be required at the producer plant. For delivery of the gas at atmospheric pressure high initial pressures and velocities are not advisable, so that the cost and upkeep of the compressors would be comparatively low

Other advantages of this system are that the sub-division of the power can take place to almost any extent, and the quantity furnished can be easily metered. The Popp compressed-air system in Paris is similar in many respects to the power-gas transmission scheme, and serves as a guide in the solution of the many problems that necessarily spring up in connection with the new system. In the Popp pneumatic system, air compresed at from 50 to 100 pounds per square inch is delivered through piping to the various consumers The line is satisfactory as regards leakage, but the efficiency is somewhat low. Under the most favourable conditions the combined efficiency of compressor piping and motor is not higher than 50 per cent. This defect, however, would not be seen in power-gas transmission. At equal pressure about seven times as much energy is stored in producer gas as in an equal volume of air. A good air motor requires 450 cubic feet of air at atmospheric pressure per 1 horse-power-hour, while a gas engine will produce the same power for only 60 cubic feet. The advisability of generating electricity at the pit's mouth has caused some discussion of recent years. It would be, however, much cheaper to set up a producer plant at the pit's mouth and pipe the gas to the various industrial centres where it is required for electric generating, heating and furnace work. There are many power-gases available, but the cheapest and most reliable seems to be that of Dr. Mond. In the Mond system of gas production cheap "slack" can be used, and the heat energy can be extracted from it in connection with the recovery of the valuable by-product ammonia, the coal bill is nullified, and thus the gas is produced for practically nothing.

Indeed, so cheaply can this gas be produced that the South Staffordshire Power Gas Company offer to deliver it to the consumer at *2d* per 1,000 cubic feet.

### THE BEST PRESSURE

Careful consideration has to be given to the best initial pressure and velocity of the power to be transmitted. Also evidence as to whether it would be more economical to use power gas as compressed air is used in Paris should be carefully weighed. That is, a certain amount of work would be got out of the gas by virtue of its high pressure, and when it has expanded down to atmospheric pressure it would be used in the gas engine.

A formula connecting the indicated horse-power required to compress the gas ($n$), the initial pressure ($p$) and the brake-horse-power contained in the gas ($n$) has been given by the author in a paper before the Institution of Electrical Engineers in 1904. Briefly, this formula was obtained as follows:

At a temperature of 60 degrees F. in the expression $pv = cT, pv = 35,434$, the density of producer gas being 0.78. Assuming that 70 cubic feet of producer gas at atmospheric pressure will, in a gas engine, give 1 brake-horse-power, the brake-horse-power transmitted through a main $= up, d^2$ where $u =$ initial velocity in feet per second and ($p$) the initial pressure where the final pressure is atmospheric, ($d$) being the diameter of the pipe in feet.

The number of horse-power ($n$) required to compress the gas (assuming isothermal compression) is found by applying the formula: Work done per pound $= p, v, \log_e r$.

Assuming a compressor efficiency of 0.8, and that $pv^{1 \cdot 3} = C$, then:

$$n = O\ 1{,}058 \log_e r \left( \frac{p1}{2{,}117} \right) N$$

From the above formula the initial presure and velocity of the gas, the

diameter of the pipe and the horse-power of the compressors required can be calculated. Thus, for 20-mile transmission schemes, if $N = 6{,}000$ B. H. P. and $P1 = 1\frac{1}{2}$ atmospheres $n = 257$ I. H. P. with $1\frac{1}{2}$ atmospheres, the line efficiency is 95.9 and the diameter of the main is 1 2/3 feet.

Including the cost of working the compressors, an initial pressure of about 5 atmospheres would be most economical, the horse-power of the compressors would be about 1,000 I. H. P., and the diameter of the main would be 1 foot.

The gas might equally well be transmitted a much greater distance. Gas transmission-line losses are much less than those of electricity and water, yet electricity, water and oil are transmitted hundreds of miles. For the supply of Coolgardie, water is pumped through a pipe line 352 miles in length, and in the United States petroleum is piped from Ohio to New York harbour, a distance of over 400 miles.

### LONG-DISTANCE GAS TRANSMISSION

Many instances of long-distance gas transmission are actually in existence. In the States, again, gas is often piped up to distances of 200 miles, while even in England an area of over 160 square miles is supplied with Mond gas by the South Staffordshire Gas Company. Professor Burstall has shown that Mond gas may be transmitted as much as 196 miles with economy, and, therefore, it seems well within the bounds of possibility that in the future London may be supplied with producer gas from the Staffordshire coal fields for heating, cooking and electric generation. This would entirely obviate the smoke nuisance in London, and enable this great commercial centre to be a sanitary and hygienic city.

Mr. A. J. Martin, in his paper on "A General Supply of Gas for Light, Heat and Power Production," presented an interesting scheme for the possible supply of coal gas to London from the South Yorkshire coal fields.

Estimating the yearly consumption of gas in Greater London to be, roughly, 40,000,000,000 cubic feet, Mr. Martin calculated that the cost per 1,000 cubic feet of gas to cover the annual compressure and transmission costs would be $1\frac{1}{3}d$. The actual cost of gas delivered to the compressors was $5\frac{2}{3}d$ per 1,000 cubic feet, thus bringing the total cost of gas per 1,000 cubic feet delivered to the London companies to *7d;* to cover leakage and distribution to $7\frac{1}{2}d$.

Now suppose the same quantity of Mond gas was transmitted. The annual line and compression costs would be the same as before, so that the price per 1,000 cubic feet to cover this depreciation, etc., would be 1/3*d*. But Mond gas would cost practically nothing to manufacture at the pit's mouth; in fact, it is quite conceivable that, as a by-product in the extraction of ammonia sulphate, its cost would be nil. Thus the cost per 1,000 cubic feet delivered to the consumer would be $1\frac{1}{3} + \frac{1}{2} = 1$ 5-6*d*.

### TWO ALTERNATIVE SCHEMES

In order to show how the transmission of power gas compares as regards efficiency with the transmission of electricity, the cost per Board of Trade unit at the sub-station panels has been worked out for the following two schemes. In the first scheme power gas from producers is used by gas engines to drive high-tension, three-phase alternators at a central station. The current is transmitted to five sub-stations, each of 4,400 KW. total load, where 3,600 KW. is transformed to direct current for traction, lighting and direct-current motors and 800 KW. is transformed to low-tension, alternating current for three-phase motors. The total load is thus 22,000 kilowatts. In the second scheme power gas from producers is piped from the central station to the sub-stations, where it is used for gas engines which drive the necessary generators.

There is not sufficient space here to give full details of the two estimates. An actual town in the Midlands was taken, and the central station was assumed to be three miles from the centre of the town. The producer plant is common to both schemes (which will be known as scheme A and scheme B). Only a short summary of the calculations is given. The slack suitable for the Mond process would cost 4*s* to 5*s* per ton. Allowing 4/6*d* for the selling price of the ammonia recovered per ton of coal (present price about 8*s*), the net price of coal is 6*d* per ton. Coal required is 43,800 tons per year. Therefore, the cost per year for coal is £1,095. The total number of Board of Trade units metered at the sub-station switchboard is 60¼ millions per annum. This assumes 25 per cent. load factor on total plant, including reserve. The cost of coal per Board of Trade unit is 0.004*d*. Attendance charges taken at 3/6*d* per ton, give a total of 0.032*d* per Board of Trade unit as the cost of fuel. This includes repairs and maintenance. The total cost of producers and recovery plant (allowing 25 per cent. reserve) is taken as £100,000, which, at 5 per cent., means £5,000 a year, or 0.02*d* per unit; £40,000 is allowed for the cost of land and buildings (these are quite few and small, as the greater part of Mond plant is unprotected by buildings). At 5 per cent. this makes 0.008*d* per unit at sub-station switchboard. Rates and taxes are taken as £600 per annum, i. e., 0.0024*d* per unit.

The total cost per Board of Trade unit (kilowatt-hour) as regards producer plant, therefore, becomes 0.0624*d*.

The large gas engines for the central station of scheme A were taken as of the Cockerill type. The cost of gas engines, generators of the heavy fly-wheel, alternator type, and auxiliaries for excitation is taken as £13 per kilowatt. The engine-room machinery, therefore, cost £357,000. Allowance is made for 25 per cent. reserve plant and for losses, making the total power 40,000 B. H. P.; £40,000 alowed for switchboard and various fittings makes the total cost of equipment £892,000. At 10 per cent. interest and depreciation, this gives 0.158*d* per Board of Trade unit.

Other charges are taken as in the following table:

SCHEME A.—TOTAL COST PER UNIT FOR ELECTRICAL CENTRAL STATIONS.

| | Per Unit. |
|---|---|
| Producer plant | 0.0624*d* |
| Machinery (generating sets, etc.), interest on | 0.1580*d* |
| Wages and professional staff | 0.0318*d* |
| Oil, waste and stores | 0.0300*d* |
| Rates and taxes | 0.0126*d* |
| Buildings, interest on | 0.0030*d* |
| | 0.298*d* |
| For promotion and insurance expenses | 0.02*d* |
| Total cost per unit | 0.318*d* |

In reckoning the line costs, £3,680 is allowed per mile of underground cable, i. e., £11,000 in all. From this the cost per unit obtained is 0.022*d*. Total line and sub-station efficiency is taken as 82 per cent., which means an extra cost of 0.067*d* for the loss in transmission and transformation. Each sub-station must have plant for 5,150 KW., of which 4,150 KW. has to be transformed to direct current; £4 per kilowatt is allowed for rotary converters, £2 per kilowatt for land and buildings. From these figures the total cost for the sub-station is 0.078*d* per unit sold. This allows for rates and taxes and for wages. The sum of all these figures gives the total cost per Board of Trade unit at the sub-station switchboard as 0.485*d*. This figure is certainly not too high. It means that a selling price of 1*d* per Board of Trade unit would give a good profit.

### COST OF TRANSMISSION OF GAS

We now come to scheme B. The cost of producing the gas is the same as in scheme A, i. e., 0.0824*d* per unit. Besides this there is only the cost of the line and the cost of the sub-station. Allowing, as before, 25 per cent. reserve plant, the total plant in each sub-station is 6,880 KW. Therefore, units of 1,000 brake-

horse-power could be used. The plant would be all on the ground floor, and a reservoir for storing gas would be fitted in the roof.

The line costs are made up of interest and depreciation on capital expended and cost of working the line. With this scheme it is necessary to supply boilers to raise steam for the producers. For this plant an extra cost of £1,400 per year, or 0.0056*d* per Board of Trade unit, is allowed. In scheme A the heat in the exhaust is quite sufficient to supply steam.

The diameter of the main required is 1¼ feet, allowing a velocity of 68 feet per second. The cost of the main is taken as £.25 per foot, i. e., £3,960 for three miles. Cost of excavation, etc., is taken as £1,100. Therefore, the cost per year for mains is £500, allowing 10 per cent., as before. Capital outlay on compressors is, say, £2,000, which means £200 a year. The cost of running these compressors using Mond gas is £86 per annum. The total line cost comes to £786 per annum, which is 0.0157*d* per Board of Trade unit.

### THE GAS-ENGINE SUB-STATIONS

Each station will require, including 25 per cent. reserve plant, machinery of 7,500 B. H. P.; taking £13½ per kilowatt, the total cost of plant for each station is £74,200. Allowing £4,000 for switch gear, and the like, £3,800 for piping valves and gas-holder, total machinery equipment costs £82,000. At 10 per cent. interest and depreciation, this gives 0.163*d* per Board of Trade unit. The cost of building and land, taken as double that of 5 per cent. interest, is £300 per annum, or 0.006*d* per unit.

Other costs are taken as below:

SCHEME B.—TOTAL COSTS FOR GAS ENGINE SUB-STATION.

| | Per Unit. |
|---|---|
| Machinery, interest and depreciation on...... | 0.163*d* |
| Wages and profession staff.................. | 0.068*d* |
| Oil, waste and stores....................... | 0.030*d* |
| Rates and taxes............................. | 0.026*d* |
| Buildings, interest on...................... | 0.006*d* |
| | 0.293*d* |

It is now possible to compare the two schemes, as in the following table:

COMPARISON OF THE TWO SCHEMES.

| | A. Pence Per Unit Sold. | B. Pence Per Unit Sold. |
|---|---|---|
| Central producing plant: | | |
| Producer plant.................. | 0.0624 | 0.0624 |
| Extra steam for producers...... | ...... | 0.0056 |
| Central electric generating station: | | |
| Machinery (not including producers) interest and depreciation on...................... | 0.1580 | |
| Wages and professional staff.... | 0.0318 | |
| Oil, waste and stores........... | 0.030 | |
| Rates and taxes................. | 0.0126 | |
| Buildings, interest on........... | 0.003 | |
| Transmission: | | |
| Cable........................... | 0.022 | ...... |
| Gas mains....................... | ...... | 0.010 |
| Cost of electrical units wasted... | 0.067 | ...... |
| Compressor costs................ | ...... | 0.005 |
| Sub-stations: | | |
| Electrical—Total costs.......... | 0.078 | ...... |
| Gas: | | |
| Machinery, interest and depreciation on................ | ...... | 0.163 |
| Wages and professional staff.. | ...... | 0.068 |
| Oil, waste and stores......... | ...... | 0.030 |
| Rates and taxes.............. | ...... | 0.026 |
| Buildings.................... | ...... | 0.006 |
| Promotion and insurance........ | 0.020 | 0.020 |
| Total..................... | 0.485 | 0.396 |

There is, therefore, an advantage in using scheme B of about 0.1*d* per unit, which, on the assumed load, means £23,000 per annum.

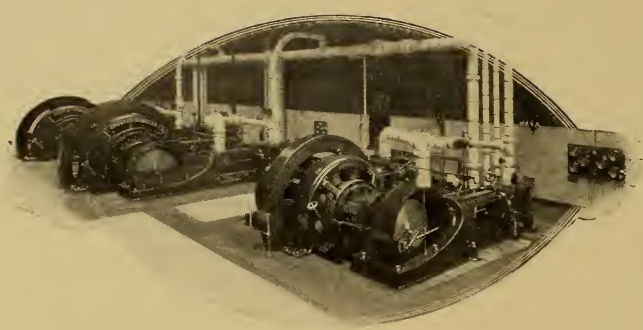
In concluding this paper, it might be of interest to compare the relative transmission costs of electric and gas power for other distances. The comparative costs of transmitting the same power by means of electricity and producer-gas for distances of 5 and 25 miles have been carefully worked out and the result shown here.

To deliver 6,000 horse-power a distance of 5 miles, the "line" costs for the power-gas scheme would be approximately £8,875, against £42,000 for the electric cable when laid. Since the cost of running the compressor was included in the former scheme, to be consistent, the cost of generating the wasted units for the line loses in the electric transmission system should be added to the annual cable expenses.

However, even as the figures stand the electric line costs per Board of Trade unit are 0.126*d*, as against only .03*d* for gas, assuming a depreciation of "line" of 10 per cent.

In the 25-mile transmission scheme the difference in line costs is almost as marked. Here the line costs per Board of Trade unit for gas are 0.25*d*, while those for electricity are 0.61*d*. From these figures and arguments, there seem great possibilities in the transmission of power by producer-gas, and wide scope for future investigation. The greatest argument in favour of such a scheme is that, although some of the author's conclusions were commented upon in an editorial note in "Power," November, 1904, no one challenged the figures. In the course of the discussion on the paper read before the Birmingham engineers (1904), Mr. W. S. Taylor stated that he had very carefully checked every one of the many long calculations made by the author. And he very kindly added that he could trace no evidence which would lead him to suppose that the case made out for gas transmission was at fault.

The chief delay in this work has been caused by other than technical considerations. But we shall witness a centralization in gas-generating stations similar to that which has occurred in central electrical stations.



# Current Topics

AMID the numerous accounts of experiments, trials, competitions and projects for flying machines, it might be supposed that some marvellous turn of invention was imminent by means of which the problem of flight was to be solved out of hand. That such may be the case we are not prepared to deny; but there is every indication that the navigation of the air, already accomplished within certain narrow limitations, will continue to work out its own development much in the same manner as other fundamental engineering questions.

As a matter of fact, the whole of the present activity in aerial navigation is but the natural result of the development of the light-weight, internal-combustion motor. The dirigible balloon of to-day is practically the same as that devised by the late Colonel Renard in his experiments for the French Government fully thirty years ago, with the exception of the substitution of the light and powerful gasoline engine for the heavy and weak electric motor employed by the French pioneer. The Wright brothers, concerning whose work so much has been said of late, began their experiments in gliding where Lilienthal left off, and while they accomplished much in the details of balancing and equilibrium, they could never have passed the limit of brief gliding flights without the advent of such an engine as the development of the automobile alone has made possible.

From the work of Montgolfier and his immediate followers down to the development of the light and powerful combustion motor within the past ten years the problem of the conquest of the air has been awaiting solution, not by some sudden discovery, but by the slow and gradual paring away of the weight of the motor, pound by pound, almost ounce by ounce, until the conversion of heat into mechanical power directly in the cylinders of the high-speed, internal-combustion engine, using liquid fuel of maximum calorific power, has been effected with a minimum of weight formerly considered impossible.

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IT is this question of the development of the state of the art, to use an expression common in patent-office parlance, which has determined the period of commercial success of many important mechanical questions. Even if Watt had not invented the separate condenser when he did, the high-pressure steam engine was bound to come, simply by the improvement in shop methods and the manufacture of boiler plate, making tight cylinders and strong boilers possible. The idea of the steam turbine could not be better presented to-day than it was by

Tournaire in 1852; but it could not have been built then, and it is only by the use of modern tools and methods that it is being built to-day. The gas turbine was described by Barber in 1791, and it has hardly yet found the state of the art equal to its commercial production, while the four-cycle gas engine had to wait nearly twenty years between conception and realization.

These are but a few examples of the manner in which the science of engineering falls into the broad scheme of evolution which governs all progress, and many others could be cited. With each advance in any department of mechanical work there comes the possibility of realization of ideas already well understood, but hitherto impracticable of attainment; but the advance thus made is positive not only for what it accomplishes in itself, but for what it renders possible in the basis which it affords for further development.

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IN our issue of last month there was illustrated, upon page 182, a powerful and effective hydraulic beam shear, designed and built by the United Engineering & Foundry Company, of Pittsburg, Pa., but, by an unfortunate error, credited to Messrs. R. D. Wood & Co. It is most desirable that this mistake should be widely corrected, and we take this early opportunity of calling the attention of our readers to the fact that this machine is the product of the United Engineering & Foundry Company.

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WE were recently shown the diagram taken of a Moscrop recorder from a gas engine of Mather & Platt, of Manchester, which was driving a cotton mill. The record was practically a straight line, and this is, after all, what might be expected from a gas engine. Producer gas, passed through a holder of some capacity, is fairly regular in quality, and should give impulses fully as regular as those given by steam from boilers containing a steam pressure that is always varying. The above firm make the Körting two-cycle gas engine, and have modified the design to suit English methods of construction and produce a really accessible engine.

In few places would an engine secure the same steady load that is obtained in a cotton factory, and cotton-factory work is so well known, as to the power required, that a gas engine can be made that will always be working very near to maximum capacity. This condition is favourable to economy, and the next few years will probably witness an enormous development in the use of gas engines in Lancashire mills, and it should be possible to use the waste heat as the means of running the mill—that supreme difficulty of mill-driving with electricity from a central station. Electrical driving from a distance will be even less economical in comparison with gas power than with steam power. It was stated recently, however, that a firm of Manchester spinners were about to take 2,000 horse-power of current from the Stuart street station of the Manchester corporation. But the promoters of transmitted power have nothing to say on the heat-supply question.

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AT a recent meeting of the Institution of Mechanical Engineers two papers were presented, one dealing with the combustion processes in English locomotive fireboxes, and the other dealing with the combustion and heat balances in locomotives. These papers were both records of tests carried out with locomotives representing what is considered to be best in modern locomotive design, the one dealing with British practice and the other with American practice. In the former case, however, the tests were made from the footplate under actual running conditions, but without the conveniences attending the use of a testing plant, whereas in the latter case the

well-known testing plant of the Pennsylvania Railroad was used, some of the tests being carried out at the St. Louis Exhibition, and the remainder after the permanent installation of the plant at Altoona. For this reason it is inevitable that the scope of the tests conducted by Dr. Brislee, of the Liverpool University, should be much narrower than those recorded by Mr. Lawford H. Fry, the engineering representative in England of the Baldwin Works of Philadelphia, U. S. A.; and, in fact, the English tests related almost exclusively to the investigation of the composition of the gases in the smoke box under varying conditions of speed and work, and with two different designs of firebox; two locomotives only being tested, whereas in the American tests four locomotives were employed, and the investigations were carried much further.

Dr. Brislee's experiments were made with two express locomotives of the London North Western Railway, one of the 4-4-0 type and the other 4-6-0 type, both engines being concerned in the heaviest and fastest express duties of that line, and the tests being made on ordinary trains in regular working, the firing being left entirely to the fireman. The latter engine had a much shallower firebox than the former, and the grate-area and length of firebox was greater, so that good opportunity was afforded for making a useful comparison between the two designs. For the purpose of the tests a small iron tube was let into the side of the smoke-box and connected by a pipe with an aspirator in the cab, the samples of the smoke-box gases being collected at intervals in glass tubes for subsequent analysis, the speed, gradient and other data being noted at the same time. The first point investigated was the variation of the products of combustion with speed, weight and gradient, and with the four-coupler engine having a deep firebox it was concluded that the loss due to the formation and escape of carbon-monoxide is greatest at comparatively low speeds with late cut-off and strong distinct blasts, while at high speeds with an almost continuous blast the combustion is much more efficient. Furthermore, the proportion of unconsumed carbon monoxide is greatest when the engine is working hardest, as when ascending a long gradient with a heavy train, under which condition the engine is almost inevitably working comparatively slow with distinct strong blasts.

The vacuum in the smoke-box was also measured, and here again the advantage is with high speeds when the vacuum is fairly uniform, owing to the steady current of the air supply, though the degree of vacuum may be relatively small. Dr. Brislee, therefore, comes to the conclusion that the combustion in a locomotive firebox is really only efficient when the speed is high enough to maintain the air supply in a steady uniform current, due to the fact that the "puffs" occur in very rapid succession, maintaining a steady, partial vacuum in the smoke-box, while the air is fed through the fire with a moderately high and fairly constant pressure. In the next series of tests, with the six-coupled engine, having a shallow firebox with a thin fire, it was found that the percentages of carbon monoxide were not so high as with the other engine, as the degree of partial vacuum was usually considerably less, due to the decreased thickness of the fire and the reduced resistance offered to the passage of air, as well as the larger grate area. Dr. Brislee, therefore, concludes that the thinner fire results in more efficient combustion, but a greater amount of judgment is necessary in order to prevent the fire breaking into holes and the passage of an unduly large excess of air through the fire, thereby reducing the temperature and seriously impairing the

steam-raising efficiency. As regards other losses, Dr. Brislee expresses the opinion that the loss of carbon as smoke is not excessive, while the amount of unburnt hydro-carbon is very slight, but the loss of fuel thrown out of the chimney is considerable. In conclusion he suggests that the employment of a controllable forced draught should be used to reduce the loss of solid fuel, and would do away with the dependence of the air supply upon the speed of the engine.

In Mr. Fry's paper the tests with four engines only are dealt with, two of these being large non-compound "consolidation" engines, and the other two being four-cylinder compound engines (Vauclain balanced and Cole systems) of the Atlantic type. One of the boilers had a narrow firebox and the other three wide fireboxes. Two of them had no firebrick arch and the other two had brick arches carried on water tubes. A large number of tests under laboratory conditions were made, and Mr. Fry presents the results in a series of curves and diagrams. The subjects dealt with are boiler efficiency, air supply, smoke-box temperatures, formation of carbon monoxide, loss of heat in the products of combustion, loss of heat by external radiation and the loss of imperfect combustion. As a whole, the calculations and curves presented, do not admit of convenient reference in brief, but a few remarks may be made concerning the matters dealt with Dr. Brisbee for purposes of comparison. According to Mr. Fry there is a general tendency for the loss by carbon monoxide to increase as the rate of combustion is increased, but he does not consider the loss very serious.

In his opinion the most serious loss occurs by the escape of unburnt coal when the boiler is working at full power. In one test referred to he estimates the heat of evaporation as 47.20 per cent., heat lost by external radiation, 2.36 per cent., heat lost in the production of carbon monoxide, 0.70 per cent., and the loss to be divided between the products of combustion and unburnt coal no less than 49.74 per cent. From other tests he concludes that at the lower rates of evaporation the largest grate gives the lowest efficiency, but at the higher rates of efficiency the largest grates give the highest efficiency. At low rates of combustion the most important losses are due to excess of air, but at high rates the most important losses are those due to escape of unburnt coal, so that a large grate is advantageous because it allows freer passage of air.

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IN a recent paper by R. M. Ferguson on air pumps and condensers, read before the Manchester Association of Engineers, reference is properly made to the height of the barometer as a vital point when speaking of the degree of vacuum secured by a condenser. The author says that all such statements ought to be reduced to a standard barometer of 30 inches; but it would be better, as he says, to state a so-called vacuum at its proper value of pressure, i. e., the absolute pressure above zero. Were this always done there are other matters which would become more plain. The pressure of water vapour in a condenser is always that corresponding to the temperature in the condenser, and if the absolute pressure in the condenser is not identical with this pressure of saturated water-vapour, the difference can only be due to the presence of air or some other gas. Dalton's law of mixed vapours tells us that, if air and water-vapour be present in the same vessel (with water), the pressure will be the sum of the pressure of the water-vapour proper at its temperature plus the pressure that the air would exert in a vessel if contained there alone. That is to say, any unit of space above water, no matter whether occupied by air or not, will always contain a definite

quantity of water-vapour corresponding to the temperature of the water whence it rises. If a condenser has a temperature corresponding to one pound of absolute pressure and the gauge tells that there is a pressure in that condenser of two pounds, then the extra pound is due to the presence of air. Yet, in face of this fact, how often do we see engineers pouring useless volumes of water through a condenser already amply cold; and again, how often do we see an air pump flying round at an excessive speed, in order to pump out an excess of air carelessly admitted through badly packed glands? Ordinarily in a jet condenser, says Mr. Ferguson, about 2 per cent. of the volume of the water may be taken as the volume of free air which gets into the condenser, and when this air is in the condenser its volume is increased ten to fourteen times, according to the vacuum.

The volume of air leakage depends upon the length of pipes exposed to "vacuum," the goodness of their joints and the manner in which they are rendered air-proof. But since much of the air is actually dissolved in the water, any excess of water only brings in more air and vitiates the vacuum.

The author is not favourable to the surface condenser, and indeed much of its utility is fancied, for the water from it is oily and difficult to purify; it is very apt to give trouble in the boiler, and since water must be softened for feed purposes, there are many cases where it would be cheaper to soften all the feed than to soften a part and remove the oil.

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PROFESSORS act a useful part, for they frequently stir up men to investigate matters which have been long taken for granted; and it is, perhaps, as well from time to time to stir up men's souls in respect of the faith that is in them, so that they may inquire and see if these things are so or are not. For some years it has been an article of faith among engineers that mild steel, carefully and honestly made, free from excess of phosphorus or sulphur, is a permanent and reliable material. Somewhat recently, however, the uses of advertisement seem to have found sweetness in the discovery of all kinds of faults, and one of these is the deteriorating effect of age on mild steel. All of our great steel structures were going rotten before our eyes by a mysterious effect of age, as so many old men were gradually fading away, and so on. For this reason a paper by Mr. John Heck, read last year before the Northeast Coast engineers and shipbuilders, ought not to be neglected. Mr. Heck has become aware that steel ships have been popping into the water like dabchicks for twenty years; they have gone out of the Tyne ports as ocean liners, as tramps and as battleships, and have had their share of hard knocks and bad usage As ships go, they have become old. Has their material grown old also? is the question. Mr. Heck answers no; and being a practical man and not a professor, he has had tests made on numerous specimens of Siemens-Martin open-hearth boiler and ship steel cut from old plates. The plates from which the pieces had been cut had been removed from a variety of causes, such as overheating in the furnace, corrosion wasting, damage of wreck or collision, and so on, and the tensile strength of all tested specimens was practically within the limits of the original specification. There had been no deterioration; the tested pieces bent through 180 degrees cold, and did not fracture except in one or two cases, and the material was practically what it was when new; that after years of hard work it is practically unimpaired. These conclusions were supported by the men who took part in the discussion, and it may now very well be claimed that steel which fails does so because it has not been made to quality. Steel makers do at least know what will not fail, and must be held responsible if they leave aught

in their product that does not enable that product to show in twenty years that it is as good as new.

There is still some doubt as to the ability of steel to stand corrosion so well as wrought iron, and it was truly pointed out in the discussions that it was not fair to speak of steel and iron in comparison, for, especially towards the end of the iron ships period, ship plates were the very worst. An attempt was made to produce good ship plates, and steel has been kept good by watchful care. Wrought iron still holds its own for cables, draw links, bolts and a few other articles that are better when not too homogeneous. Steel has, of course, the defects of its qualities; but the sin of ageing must not be laid to its charge if only it is honestly made.

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A CORRESPONDENT suggests that engineers should make tests on their steam boiler furnaces with a view to finding out whether the green smoke from coal would burn better if, when the fire door is shut after stoking and the air grids are opened, the ash pit dampers are closed to check the production of carbonic acid, which, it is suggested, is not favourable to flame production. Whether the chilling of the under fire would do as much harm as the non-production of $CO_2$ might do good, only actual experiment can determine. Such test might very readily be made, and the result might be of real value in solving the smoke prevention question.

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THE doubtfulness of steel and its corrodibility has brought wrought iron into prominence. Wrought iron can now be puddled in large masses, and there is a prospect of its extended use again. It is a better material for boiler tubes than steel. The best Yorkshire irons still go to the making of draw hooks, pit cage hooks, chains and parts subject to shock. Wrought iron is like a bundle of faggots. One stick may break, but the fracture will not extend through the bundle. Steel is much too homogeneous, and a crack which starts will go on until it produces complete rupture, and may do so unseen.

# WILLIAM DANA EWART

A BIOGRAPHICAL SKETCH

IT has often been stated that the inventions which, in general, have been most successful, are those relating to comparatively simple matters—things so simple, in fact, that they have been overlooked by those who might have been expected to be the first to appreciate their importance. Thus, the use of chains for the purpose of transmitting motion is a method long known and applied, and shown, in various crude forms, in many of the early treatises on mechanism. In most instances, however, the chain, as applied for the transmission of power, did not differ materially from the form originally designed for sustaining weight, and it is only within recent times that, by a simple and ingenious invention, a chain, which was at the same time a belt, was produced. How recent this invention actually is will be realized when we learn that the man to whom it is due has just passed away, in early middle life.

Prior to the work of Mr. William Dana Ewart, who died at Rome on May 3, 1908, a transmission chain consisted either of the ordinary forged-link chain, such as used for hoisting appliances, but running over pocketed sheaves, or the flat-link chain, made up of pairs of flat wrought-metal links riveted together, and running over sprocket wheels. An excellent example of the former type is seen in the chain and pocketed sheaves used in the Weston chain block, while the latter type is familiar to every one as used all over the world in the driving gear of the bicycle. Such chains have done good work; but their defects have limited their use to transmissions for which the ordinary belt was unsuited, as when a positive relation of the sprockets is essential, as in textile machinery and similar work, or in places where the limitations in size of wheels and of distances between centres renders a belt ineffective, as in the case of the bicycle, already cited. The great defects of such chains, apart from their cost, lie in the difficulty in making changes in length, in taking up slack, and, in general, in immediate and general application. The forged chain involves the work of the smith to close the last link, and if the length of the endless chain thus expensively made be incorrect, a link must be opened and rewelded to enable any change to be made. The flat-link chain requires the cutting of a rivet and the insertion of a new one, unless the expedient of a removable pin, with screw and nut, be used, this latter being the well-known arrangement in the bicycle chain.

In 1874 Mr. Ewart devised the form of transmission chain since known as the detachable-link type, and now used throughout the mechanical world under the name of the "link-belt." The vital feature of this invention lay in the design of a form of link which was readily detachable from its fellows at will, but which could not become detached by itself when in service.

Further, the link was so designed as to consist of a single piece, of a form enabling it to be readily made as a malleable casting. Thus, at one time the two great defects in chain-

transmission mechanism were eliminated: the defect of non-adjustability and the defect of cost, and this by an actual simplification in construction.

The result of this invention is seen in the widespread adoption of the link-belt for innumerable varieties of service for which chain was previously considered inapplicable. It was quickly adopted by the manufacturers of harvesting and other agricultural machinery, and its advantages and value as a substitute for leather and other forms of belting in machinery for elevating and conveying materials becoming evident, Mr. Ewart organized, in 1880, the Link-Belt Machinery Company, of Chicago, for the exploitation of the chain and the manufacture of machinery employing it in other than agricultural lines. The actual manufacture of the chain was conducted by the Ewart Manufacturing Company, a corporation organized for that purpose in 1875. The success of the Chicago company led to the organization, in 1888, of the Link-Belt Engineering Company, of Philadelphia, Mr. Ewart being largely interested in, and serving as president of, both companies. In 1906 both of these corporations, together with the original Ewart Company, were consolidated to form the Link-Belt Company, by which corporation the business is now conducted. The whole early history of these companies bears the impress of Mr. Ewart's genius for organization and for his ability to secure the co-operation of his associates.

Mr. Ewart's name has been associated with many other inventions for which patents have been secured; among these may be mentioned the Ewart friction clutch, which has proved valuable in numerous large installations.

About fifteen years ago uncertain health compelled Mr. Ewart to withdraw from active business, and he had since lived in Europe, retaining, however, his financial and personal interest in the corporations in whose upbuilding he had been a leader. His death, in Rome, at the comparatively early age of fifty-six years, has brought sorrow to his many and close friends, and more than usual regret to the wide circle of acquaintances which he had established.

From Portrait by G. Black & Sons, London.

ROBERT FORRESTER MUSHET

INVENTOR OF SPECIAL TOOL STEELS AND OF THE USE OF SPIEGELEISEN IN THE BESSEMER PROCESS

SEE PAGE 383

# Cassier's Magazine

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## THE MANUFACTURE OF HIGH-SPEED STEEL

By O. M. Becker

IT is pretty well known that there are three rather distinct kinds of steel, considered with respect to the method of production, namely, crucible, open hearth, and Bessemer. Only crucible steel is suitable, generally speaking, for use in tools, and especially in cutting tools. It is by the crucible process that high-speed steel is produced.

This process, the simplest of those in use, is centuries old, reaching back to those days in the misty past into which history has not penetrated. A simple and crude method still practised among certain hill tribes of India, whereby they produce the superior steel called wootz, is substantially that followed in the same regions twenty or thirty centuries ago. The modern method of producing crucible steel is essentially the same as that by which wootz is made; but of course, in its details, it has been greatly improved. And though the simplest of the three processes now in use, it is by far the most costly. Briefly, it consists in placing together in a clay or graphite crucible the iron and charcoal, wood or other substances which are to enter into or affect the final product; setting the crucible in a furnace and melting its contents; and afterwards "working" the product to secure density and form necessary for use.

Crucibles, as used in steel making, are in America usually of graphite and clay, half and half. In Europe clay crucibles are quite generally used. The latter have certain advantages, but are much less serviceable than those containing a considerable amount of graphite. The charge, exactly proportioned in the "mixing room," rarely exceeds 125 pounds, and frequently is as small as 50 pounds. The amount of iron, charcoal or coke (in case carbon is to be a constituent), metallic or ferro tungsten, molybdenum, titanium, or whatever other agent or combination of agents is used for hardening, is determined by the formula followed; and this, of course, is a result of much experimenting with various mixtures. A formula once adopted, however, it is religiously and precisely followed until changed, in order to preserve as nearly as may be absolute uniformity in the product.

The crucible is most commonly charged cold (though in European practice it is common to charge the crucible through a funnel, while it is in the melting hole, or, perhaps, in a pre-heating furnace), since this permits a careful arrangement of the stock used in charging. The hardening agents are preferably placed at

CRUCIBLE CAST-STEEL MELTING FURNACES. SAMUEL OSBORN & CO., SHEFFIELD

the bottom of the crucible, and the small pieces of iron carefully packed over them in such a way as to exclude as far as possible any gases which might otherwise be absorbed from the melting hole before the closing of the crucible. The crucible is then lowered into the melting hole and a cover placed over it to keep out gases, and the melting hole itself carefully sealed up.

The method of placing the crucible in the melting hole, and removing it again, has changed little since time out of mind. The melter, or more often his helper (sometimes called "puller out"), grasps the filled crucible by tongs shaped to fit its sides, and, straddling the hole, lowers away until the crucible rests upon the floor of the hole or upon a suitable bed of fuel, as the case may be. In like manner the crucible is "pulled" after the melt is ready for pouring.

Evidently this is very hot work. Indeed it is customary for the "puller out" to swathe his legs in wet cloths to avoid being scorched; and even then he not infrequently catches fire and has to extinguish himself. In strictly modern practice, especially where large quantities of metal are made, mechanical methods of handling are employed, generally an overhead trolley hoist operating the tongs. This saves much labor and eliminates much of the inconvenience.

The melting hole usually is one of several, perhaps as many as twenty. Each hole commonly accommodates four to six crucibles; and generally all are connected with the same main flue and stack, though in other respects each is practically a separate furnace. Where gas is used for heating, the furnace is of the regenerative kind, with checkers and reverser, and is provided with suitable valves and dampers for regulating the temperature. For high-speed steel melting this type is most satisfactory because of the ease with which the temperature can be maintained at a very high point and also kept uniform for any desired time. In ordinary crucible steel practice the

MELTING DEPARTMENT CAMMELL LAIRD & CO. LTD., SHEFFIELD

MELTING HIGH-SPEED STEEL. CAMMELL, LAIRD & CO., LTD., SHEFFIELD

POURING HIGH-SPEED STEEL. CAMMELL, LAIRD & CO., LTD., SHEFFIELD

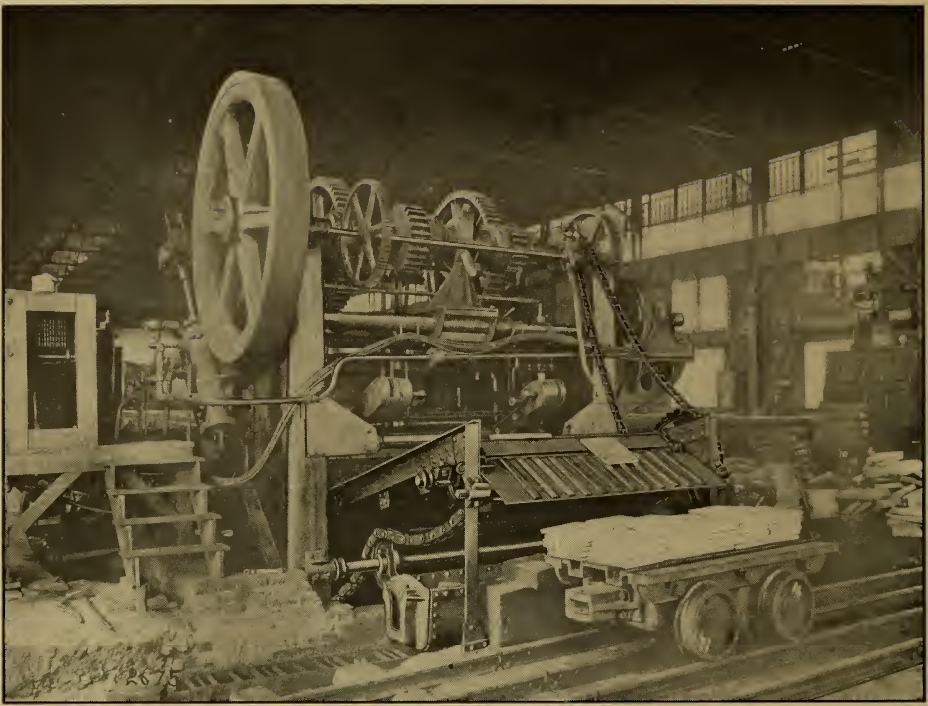
draught is reversed about every half-hour. The high temperature required for melting high-speed steel, however, makes it necessary to reverse as often as every twenty minutes.

In some cases the melting hole is an ordinary coke hole, also with drafts and dampers for controlling the temperature, which is more or less filled with coke or anthracite piled around the crucibles. The long time required for melting high-speed steel makes it necessary to replenish the fuel one or more times during a melt, which is a disadvantage, for it involves more or less cooling during the operation.

The heat of the melting hole is gradually brought up to the high temperature necessary, and maintained as long as may be required. Ordinary crucible steel melts in 2 to 4 hours, and rarely requires more than 3 hours, if the stock is not in too large pieces and the furnace is kept well regulated. High-speed steel, however, requires much longer. For those steels containing considerable manganese, 8 hours is not unusual; and for the very best grades of high-speed steel the melting may require as much as 10 hours and even more. The melter's experience is his chief guide in estimating when the charge may be expected to be about melted; and when he judges this to be done, the melting hole and crucible are opened for examination. For the most part the melter depends upon his eye in determining the readiness or unreadiness of a melt. Evidently, a great deal depends upon his judgment in this matter; for if he makes a mistake the melt is likely to be a loss.

POURING CRUCIBLE STEEL. THE FIRTH-STERLING STEEL COMPANY, MCKEESPORT, PA.

As is the case with other crucible steels, a melt of high-speed steel is not poured immediately after it has become sufficiently liquefied; it is held at a high heat for a time ranging up to two or three hours (usually

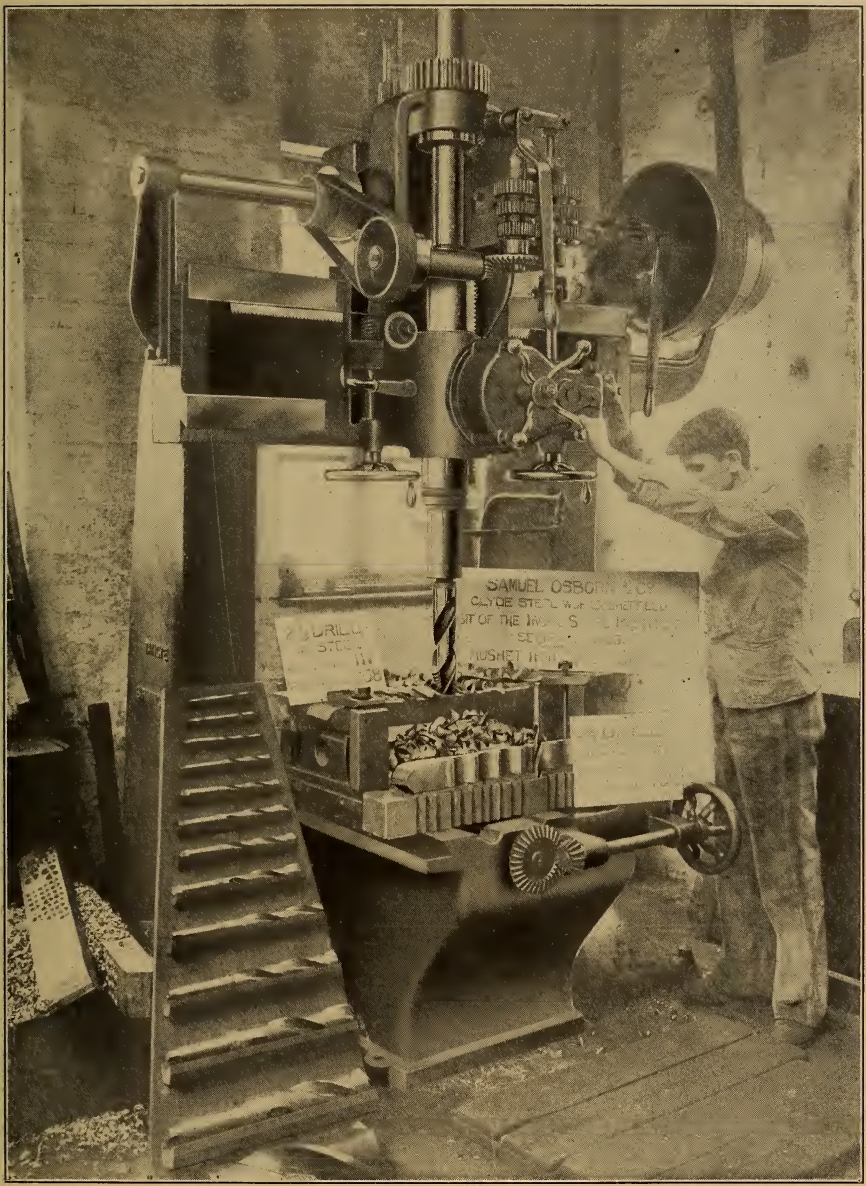


STEEL BILLETS COMING FROM THE SHEARS, SHOWING THE ARRANGEMENT OF LINK-BELT APRON. ALAN WOOD IRON AND STEEL COMPANY, CONSHOHOCKEN, PA.

it is much shorter), to be *killed* or *dead-melted,* as it is called. This standing in a melted state has an important effect upon the density and uniformity of the ingot, due, it is thought, to the escape of certain gases, the thorough diffusion of the several constituents of the melt, and perhaps also to certain chemical changes of an uncertain nature. Unless a melt is thus killed, the steel is likely to be more or less porous and otherwise imperfect.

The pouring of the melt is precisely the same as in the case of ordinary crucible steel. The contents of the crucible must not be allowed to cool to such an extent as to lose to any appreciable extent its fluidity prior to pouring into the ingot molds. The slag having been skimmed off, the crucible is emptied into the ingot mold. The latter is customarily deep, but small in section, usually not much exceeding 4 × 4 inches, is made in two parts held together by keyed rings, and is commonly smoked on the inside before using, in order to give a smooth-surfaced ingot and to prevent its sticking to the sides of the mold. Inasmuch as the stream of molten steel being poured into the mold must not come into contact with the sides, it is evident that "teeming" or pouring the melted steel to the bottom of a mold of this kind involves a very high degree of skill.

Ingot molds, as used in making high-speed steel, usually hold the contents of but a single crucible, though sometimes several are emptied into a single large mold when a large billet is required for any purpose. The ingots, after removal from the molds, are "topped." That is, the tops are broken off to remove any defective portion such as is likely to be found in this part of an ingot. The remaining portion of the ingot is sampled; and if upon analysis it is found satisfactory and no defects appear in the structure, it is put under the




DRILL PRESS FOR TESTING HIGH-SPEED STEELS. SAMUEL OSBORN & CO., LTD., SHEFFIELD

hammers and thoroughly worked out into billets. The billets are again inspected, and if perfect, go to the hammers or rolls, as the case may be, for finishing into the required shapes or sections. Hammered bars are likely to be somewhat better than rolled ones; but the custom is to roll all small sections and hammer the larger ones. Both hammering and rolling must be done at a heat considerably higher than that customary in the case of ordinary steels. High-speed steel is so dense that it works well only when at a red heat or hotter. If hammered or rolled at a

lower temperature the metal does not flow freely and uniformly under the blows or pressure, and cracks are likely to develop. The internal strains set up under these conditions frequently produce cracks long after the bars have been passed as perfect and more than likely put to use.

High-speed steel being self-hardening, the bars when finished are exceedingly hard and require annealing except for a very few uses. Unless annealed the bars cannot well be used for even such tools as require only to be ground and inserted in a holder, owing to the difficulty of breaking off what may be wanted; and it is utterly impossible to machine high-speed steel in this condition into any of the many special forms required. The hard bars can, of course, be forged; but even in this case it is much better to use annealed stock, for several reasons, the most important of which is that annealing relieves the internal strains set up in hammering or rolling and obviate the possibility of future flaws or cracks. Also, the structure of the steel becomes uniform, homogeneous and tenacious; and according to the experience of some, its life is increased.

The annealing is done in ovens of the customary type, the temperature being gradually brought up to a bright red heat, and the bars then removed and slowly cooled. Much better results are obtained in those cases where the bars are allowed to cool in the oven itself, the heat being shut off soon after the desired temperature has been reached. The oven is then allowed to cool down slowly. As in the other processes, great care must be taken that conditions are just right, else there is likelihood of the steel coming out poor or indifferent in quality, even when the mixture is good.

Those familiar with the process of making ordinary crucible steel will doubtless have noted already that the process of making high-speed steel differs in few important respects from the former. In general, the equipment used and the methods practiced are identical. The chief difference is in the stock put into the crucible, and in the exceeding care exercised throughout in producing the high-speed steel. In a mill which endeavors to make and keep up a reputation for producing a superior quality of high-speed steel, the extent and frequency of the examinations and tests of stock in process of manufacture are surprising. The ingots are carefully inspected before as well as after "topping," and the lower portion is sampled for analysis. The topping itself, breaking off the upper part of the ingot, is intended to remove any possible inferior metal or defects, frequently found in that portion of the ingot. The billet is again inspected; and each separate bar likewise undergoes examination for defects. The bars are generally "pickled" to make any defects more easily discernible, if any exist. If defects appear at any time in the course of all these inspections, the material is rejected if inferior in quality, or remelted if merely defective in structure.

Considering the care necessary in its manufacture and the high skill required in the workmen, it is not at all singular that high-speed steel continues to sell at a price extraordinarily high, compared with the price of other steels. There are, however, additional reasons for the high price which it commands on the market. The quantity produced per melt is very small, compared with that produced by other methods. This small quantity, however, requires as much fuel for melting as would suffice for half a ton or more of Bessemer or open-hearth steel. The coal required, when used as producer gas, runs generally from one to two pounds per pound of steel, and not infrequently more still.

The materials used are necessarily of the purest, and certain of them are rare; for both of which reasons their cost is very high. Some mak-

ers use only the purest Swedish and Dannemora iron, saying that these alone are free enough from sulphur, phosphorus, and other impurities to give the best results in high-speed steel. These irons are considerably more costly than even the best of ordinary kinds. A number of makers, however, utilize good qualities of native muck bar, saying that these give results as good as can be obtained; but these extra pure irons also have a higher price than the ordinary. The tungsten, molybdenum, and other hardening metals, vanadium especially, are rare, their ores being found in but few places, and those usually not easily accessible. These ores are commonly reduced in the electric furnace, sometimes to the metallic, sometimes to the ferro state, and at others to the ferro-alloys, either of which can be used in the manufacture of high-speed steel. The prices of these metals range in either state from $0.40 to $6.00 per pound.* Since the proportion of hardening metals is not infrequently above 20 per cent., and in some cases is considerably greater, it is seen that the cost of material alone is something quite different from what it is in the case of ordinary steels.

In spite of the keen competition among makers, the price of high-speed steel has remained practically where it was when first put upon the market, for the best grades not far from $0.70 per pound in small quantities. This seems altogether out of proportion, at first thought, even when the high cost of manufacture is considered. It is to be remembered, however, that this includes the as yet high cost of marketing; and must, of course, cover, in part, also the great expense of continued experimentation necessary to determine the most desirable composition and method of production. The cost of certain of the hardening constituents has increased considerably of late, owing to the large demand; but it may be expected that new sources of supply will be located and that the methods of extracting the metals and ferro alloys will be so simplified that this cost will be materially reduced. even in the face of a continually increasing demand.

*The prices quoted in the United States in March, 1908, were approximately as follows:

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|---|---|
| Tungsten | $0.75 |
| Vanadium | 6.00 |
| Molybdenum | 1.50 |
| Titanium | 1.00 |
| Chromium | .37½ to .75 |

The figures given are the price per pound of the contained metal in the ferro, or metallic, state. Swedish iron was at the same time quoted at about three cents per pound.

# THE PROPER USE OF COST-KEEPING SYSTEMS

By Sterling H. Bunnell

THE past twenty years have seen a great increase in the interest taken by all enterprising shop managers in the subject of cost-accounting. Various excellent systems have been developed, some by trained accountants, whose experience has been gained in keeping the books of large corporations; others by practical mechanics, who have been forced by the necessity of keeping track of the outlay of the organization under their control with relation to the income derived from the product of the shop into devising a system which might enable them to obtain the necessary information. The literature of the technical press, as well as the numerous formal works on the subject which have been published during the past few years, has brought into general knowledge the details of numerous successful methods of cost-recording. There is much similarity between the various methods which have been described, as well as much diversity in detail, so that the requirements of almost any imaginable manufacturing business can be fully satisfied by more than one existing system of cost-keeping.

While the absolute necessity of proper attention to manufacturing costs is well established, it is surprising to note that systems which have been found satisfactory in one instance have, when put into practice in another shop, been found to fall far short of the desired results. In most cases this condition shows no fault on the part of the system, but indicates rather the failure of the management to make proper use of the means it has provided. Sometimes a cost system, carefully developed to meet the exact requirements of the factory, has been allowed to fall into inaccuracy through carelessness of the cost clerks, or willful blundering on the part of the shop force, or an attempt to reduce the expenditure for cost-keepers' salaries to such a point that the department cannot keep up with the work as it comes in, with the inevitable result of mistakes in the records, neglect of indexing, and general deterioration of the whole department. In some cases a strange indifference on the part of the very men who paid for the introduction of an elaborate system has allowed the records to go unheeded, passing over the records of costs of individual orders, as well as the monthly summaries of the values of work and expense in the various departments, until financial disaster has come upon the business, in spite of the warning which might have been given by the cost department.

To make proper use of cost records, two conflicting principles must be clearly grasped, and reconciled, as far as possible, under the circumstances of each particular case. The cost records must be detailed to the last degree, so that discrepancies, due to carelessness or growing inefficiency, may be tracked down and the responsibility placed where it should fall. At the same time, the results must be summarized so briefly and concisely, and in so well ordered a manner, that the overworked superintendent or foreman may keep track of the efficiency of his employees, the busy manger may watch the increasing or decreasing cost of similar pieces of work, and the more or less careless salesmen may take warning

by the failure of the shop to make profits on certain work when the opportunity is afforded them to figure on the next job. The cost summaries themselves will naturally be on sheets of paper which will pile up rapidly as the shop orders are completed. These sheets should be kept in numerical order, well bound in loose-leaf covers or transfer binders, so as to afford the maximum protection from damage from the frequent handling they will receive. But as this arrangement is neither alphabetical nor in order of size of machine or material, a good card index must be provided, for the double purpose of finding the cost of any order by the name of the customer with approximate date or by the size of machine. The alphabetical index by name of customer is very easily kept up by providing a card copy of each shop order to serve itself as the index card arranged by name of customer, or if this is inconvenient, an extra paper copy, to be bound in a loose-leaf holder in which the sheets are arranged alphabetically for the same purpose. The index by names of machines, buildings, articles, etc., must usually be a separate card index, arranged carefully with proper guides, so that all orders for similar machines may be filed together and similar machines of different sizes may be readily located by any one familiar with the use of the card index in general. The tab system could be used for this purpose in combination with the alphabetic index, each card having a properly located tab to indicate the class of product called for.

The routine work of the cost system must be kept up promptly and accurately. The cost-keeper should be thoroughly impressed with the fact that his records are for general use by all persons interested from a proper standpoint, not a set of secret books kept for his own peculiar benefit and for the sake of affording him means of earning a living. He must expect to be called upon frequently for unusually prompt completion of a cost record, or for abstracts or transpositions of a number of sheets, as well as for time-cards of individual workmen, by which their efficiency may be demonstrated for the convenience of the shop foreman. He must be a man who will stand upon his rights with regard to keeping his record accurate and his system in order, while he must be accommodating to the utmost possible degree in his relations with those men who have reason to make demands upon him. He must be supplied with a sufficient force of assistants to make the routine work of the cost system a comparatively easy task under ordinary conditions, employing a moderate portion of the day's time of the whole force. When this is properly arranged, rush times can be provided for without slighting the work, or requiring so much overtime as to weary the force to the point of carelessness.

The cost sheets on which the daily details are entered must be so arranged that, upon completion of each order, totals can be quickly footed up, without extended posting, cross-addition and checking after the completion of the shop work. It is also necessary that the addition to cover the shop burden be made on a sound and sensible basis, and that the rates be cautiously altered from time to time with regard to the future, so as to avoid abrupt change. It is easy, by providing multiple columns, to carry separately the weights of each class of material—for instance, cast iron, steel, brass, babbitt, etc.—and to post the cost of labour in a system of groups, so that with a steam engine, for instance, the labour on cylinder and piston, frame and bedplate, main moving parts, valve gear, etc., may be totaled separately; and to provide one or more burden columns in which the addition for shop expense may be entered independently of material and labour. With such a cost sheet it is possible to make up a total in a few minutes, and to obtain the separate weights of the cast iron,

steel and other materials, and separate total costs of the labour on each main division of machine, or, if preferred, separate totals of labour cost in the different trades which may be involved; and outside of the direct cost of material and labour to carry the burden addition, so that a grand total of all the items of cost may be promptly made up.

If a properly summarized cost sheet is provided, the selling price for all work done on open order or without a previous estimate can be made after the cost is finished, making the invoice only after the facts as to the cost are in hand. It is equally possible to know, within a few minutes after a contract job is completed, whether the cost is sufficiently low to make the job profitable.

While selling prices cannot be always made from costs, it is certain that costs must be made to correspond with selling prices, or the factory will go to the wall. The burden addition is of the greatest importance in this connection. There is little hope for the financial success of a shop whose owner cannot see the difference between the true net profit and the margin which generally exists between direct cost of material and labour and selling price. By carrying continually in connection with the direct cost the addition for burden, the apparent ample percentage which is commonly supposed to swallow up the whole shop expense will be seen, in many cases, to afford only a small margin of profit.

For keeping up the efficiency of the shop the fullest details of the cost records must be available. The use of the job-ticket system, by which the time of each man on each single job is reported on a separate slip, affords the means of investigating the efficiency of each operation whenever desired. With the job-tickets kept behind guide cards bearing their order numbers, and further arranged by groups covering general sections of the work, the efficiency of any particular workman may be quickly investigated by comparing his time on jobs which he is known to have handled with the time of other men on similar jobs. The cost of doing work on one tool may be compared with the cost of making the same piece on other tools, or the cost of making a piece last year may be matched against the cost of making it this year. By referring to the group totals, the cost of the valve gear of one engine may be compared with the cost of that of a previous engine, to show the results of improvement in design or improvement in machine operation, or better attention to work in assembling, and any of these may be traced to the last item by reference to the proper job-tickets. Making such comparisons takes time, and they will be shirked unless the proper person sees that the figures are brought to the attention of the men concerned. A good way is to provide a book for each man interested, in which the summary of each successive order is entered as the order is completed directly under the summary of the last similar job.

As important as the cost system is for showing what has been done, its value is still greater for showing what should be done in future. Nine-tenths of the estimating done in bidding on new work is based on guesses. With a well-indexed cost system covering the records of two or three years it is not difficult for the sales department to obtain quickly the cost of a prospective piece of work, by simply making up this total from the details of portions of similar work previously carried through. Thus, if a steam plant is required, consisting of three boilers, one vertical cross-compound engine and one vertical simple engine of smaller size, the cost can be closely approximated by adding together the previous costs of two boilers of slightly smaller size, making a suitable increase to cover the increased weight of the new boilers and adding for the third one, and the costs of a previous simple engine, doubled to cover the cross-com-

pound, but with one of the fly-wheels deducted, since the compound will have but one, making at the same time the necessary addition for the extra cost of cast iron in the heavier wheel which will be required, and an approximation of the extra cost of the larger cylinder required for the low-pressure engine, and similarly arranging for the probable cost of the second unit. This summary can be quickly brought together, and is infinitely more accurate than any rough guess based on the cost of a similar plant as a whole. The effect on the selling price of a change in the market value of raw material can easily be provided for by making the necessary addition for the increased cost of the number of pounds of this class of material which previous summaries show to be required. The price of a homogeneous machine or device may be compared with that of a similar device on a pound basis, dividing the total cost by the total weight of material, and this will be found a very useful check in many cases. Where an estimate is required for special work not involving large numbers of similar pieces, working from actual cost records of portions of similar work gives much better results than the usual way of guessing the probable expense of lifting a casting from the floor, bolting it to a machine, taking one cut, etc., and the results secured will be found to vary much less in the long run, besides being quicker and less expensive.

The indexing and profitable use of the cost system in distinction to its initial establishment and daily routine have not received the attention they deserve. The expert accountants engaged to establish the system are, in most cases, dismissed as soon as the routine is fairly understood by the shop force, while the men who should assume the responsibility allow themselves to become engrossed in other matters. The condition is similar to that often found in shops which have been provided with a full equipment of high-speed steel tools, and being without progressive foremen, find the workmen dropping their machines back to the old moderate speeds, and forgetting that better results are expected. It is useless to purchase expensive steel for tools which will be turned over, without further attention, to ignorant and prejudiced workmen. It is equally foolish to install an expensive cost system, to pay the men necessary to keep the system up, and then to allow the record books to lie clean and unused in a safe but inaccessible storage vault.

# RAILWAY BRIDGES OF MODERATE SPAN.—II.

By Conrad Gribble, A. M. I. C. E.

THE DEVELOPMENT OF MODERN WROUGHT-IRON BRIDGES

WHEN the fact that girders could be made out of boiler plates occurred to engineers (and it is rather singular that it was not apparent sooner) it led to a revolution in bridge-building. At the same time that Robert Stephenson was building his tied cast-iron arches over the Tyne he was also engaged with the Britannia tubular bridge over the Menai Straits, which was the first great bridge constructed of plates. He had intended to stiffen it with suspension chains, and he, therefore, carried up the towers of the bridge to a great height above the "tubes." When these great girders were floated and raised hydraulically into position, it was found that they were sufficient in themselves, and the chains were, therefore, not added.

Stephenson also designed the tubular bridge, of 225 feet span, over the river Aire at Brotherton (Figs. 10 and 11) which carried the York & North Midland Railway's branch to Knottingley. This was opened in 1850, the same year as the Britannia bridge, and there was no provision for suspension chains here, as the span was only half that of the larger bridge, and the girders were considered sufficiently strong in themselves. After this date wrought iron as a material for girder-making found general favour, and its advantages, especially in the perfect pointing of one piece to another by efficient rivetted joints, and also in its strength to resist tension, were soon apparent. At Brotherton there were two independent tubes, each carrying a single line; but they were, unfortunately, extremely narrow, so much so that it was very dangerous for anyone to lean out of a window as much as a foot or even less. Cattle were injured by their horns projecting from the trucks in which they were conveyed and coming in contact with the sides of the tubes.

A somewhat unusual course was adopted to improve matters in this respect. The roof of each tube was cut through longitudinally along the entire length of the bridge and the two sides then forced apart, while a new strip was rivetted in between them. The projecting stiffeners inside the tubes were cut away as much as possible, so that a few inches of additional width were obtained.

Any such construction is, of course, bad from the point of view of maintenance, as free circulation of air is prevented, and the absence of light renders inspection difficult. Tunnels are not such a popular and desirable feature of railways that it behooves engineers to build them in iron in place of open bridges.

When the span of girder bridges was less than about 200 feet it was not thought desirable to make an iron tunnel, but what are known as box girders were employed. These had most of the objections of tubes, except that their interiors were free from smoke and that they were not tunnels. The internal corrosion was, however, an unknown quantity and not a negligible one. Large girders of this type were made to allow of a man walking through their entire length to scrape and paint them, but it must not be supposed that the quality of the paint work inside was equal to that outside.

Maunby bridge (Fig. 12) over the

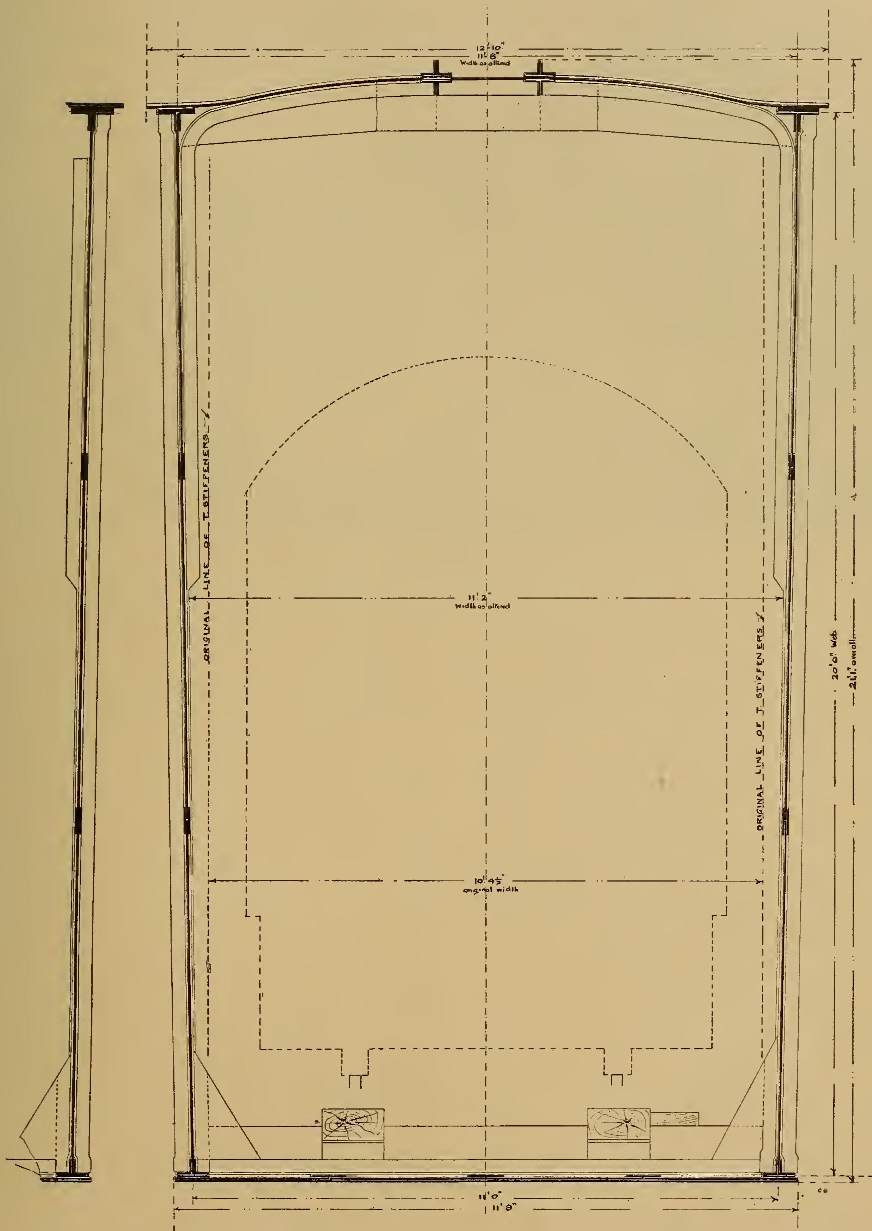



FIG. 10.—BRIDGE OVER RIVER AIRE AT BROTHERTON. TWO WROUGHT-IRON TUBES, 237 FEET SPAN. ROBERT STEPHENSON, ENGINEER, 1850. REPLACED 1903

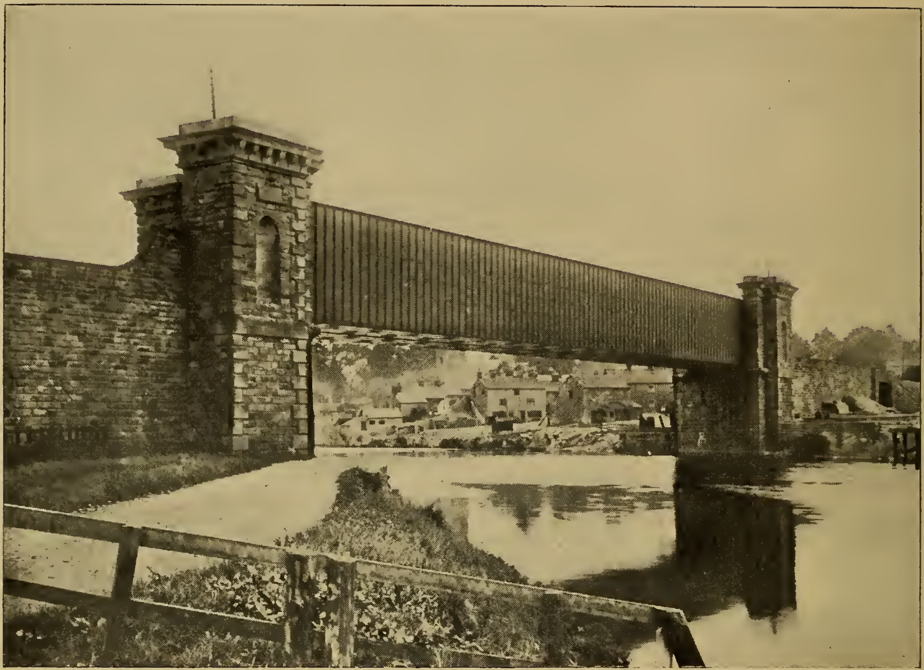


FIG. 11.—BROTHERTON TUBULAR BRIDGE OVER RIVER AIRE

river Swale was of this type, and is fairly typical of a considerable number of bridges put up in this country. The girders were cellular, two upper divisions forming the compression flange. The idea existed that wrought iron was not to be trusted in compression except in cellular form. At the Britannia bridge such a large area of metal was required to take the compressive stresses that a cellular construction was justified; but in these smaller bridges it was not required, and the inside of these cells was, of course, never cleaned, scraped or painted after the girders were once completed. The working stresses in wrought iron were, as a rule 4 tons per square inch in compression and 5 tons in tension; but after deducting the area of the rivet holes in the tension flanges the net areas of the two flanges were about equal. Bridges similar to this one at Maunby were built over the Spey between Inverness, Aberdeen, and over the Trent at Torksea at about the same time. The girders over the Spey bore a great resemblance to those over the Swale, but are of much greater span. The Torksea box girders were continuous, and were the first made on that principle, which was only sanctioned by the Board of Trade after a great dispute with the engineer, Henry Fowler. On account of the impossibility of properly examining and repainting box girders, they have quite lost favour nowadays. The plates might rust nearly completely through before anyone was at all the wiser. Attached to a single web girder, the cellular flange was obviously an advantage in the point of strength and resistance to buckling; but when there were two webs its need is not so apparent, as the webs would perfectly stiffen a simple horizontal plate flange against any tendency to buckle.

Many other types of cellular flanges were employed, and the two shown in Figs. 13 and 14 were designed by Mr. (afterwards Sir) Thomas Bouch in 1856 and 1862. The first example shows what must

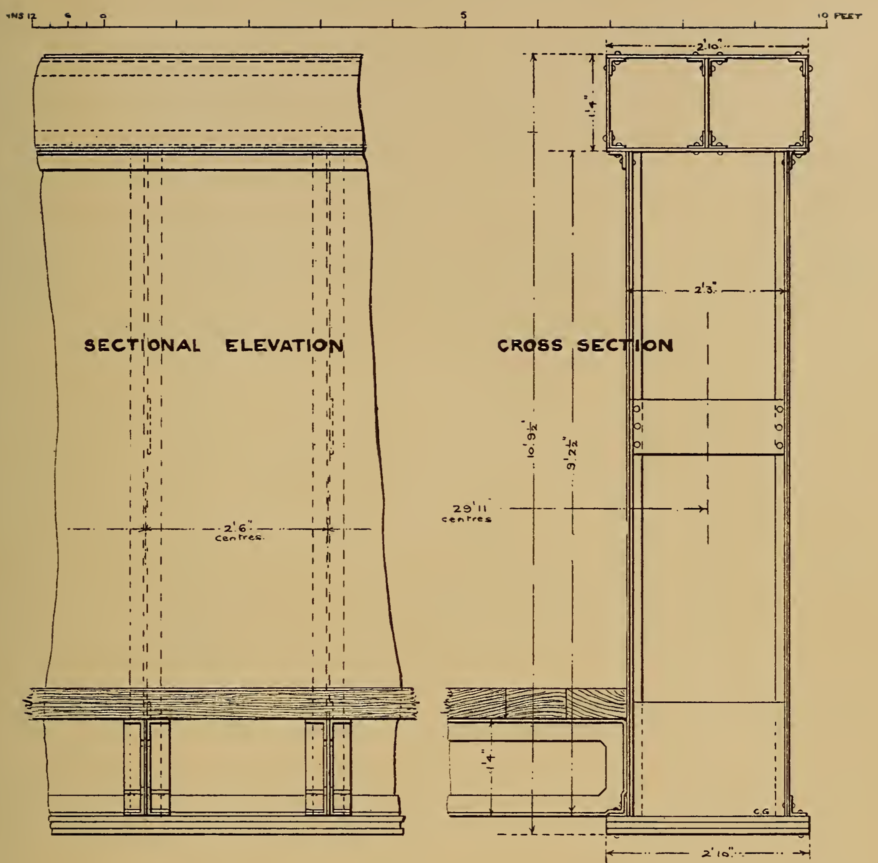



FIG. 12.—GIRDERS OF BRIDGE OVER THE RIVER SWALE AT MAUNBY. LENGTH 155 FEET. THOS. GRAINGER, ENGINEER, 1852

have been some of the most difficult girder work ever accomplished. The trouble and cost of forming the various curves in the plates of which these girders are made was out of all proportion to the value of the idea. The girders were not parallel, but hog-backed, and the flange plates and web plates had, therefore, to be curved both transversely and longitudinally. The radius of the upper flange plate was much flatter than that of the web plates, and the latter had, therefore, two radii, since they had to be fitted close to the flange plates along the row of rivets.

The girders at the Musgrave bridge, made six years later, were much simpler, as there were no curved plates, and as the bridge is a deck bridge—that is, one in which the permanent way is supported immediately above the girders—the tops of the girders were flat and horizontal. There was no need for the upper flanges of these two girders to have been different from the lower ones, and in the case of the Musgrave bridge it would have been better to have stiffened the bridge as a whole against buckling than to use these celluloid flanges. The cross bracing shown in dotted lines was added by Mr. W. T. Cudworth in 1894, previous to which date the bridge was altogether unprovided with any such bracing. The lower flanges were also increased considerably, and the bridge rendered stronger and more up to date.

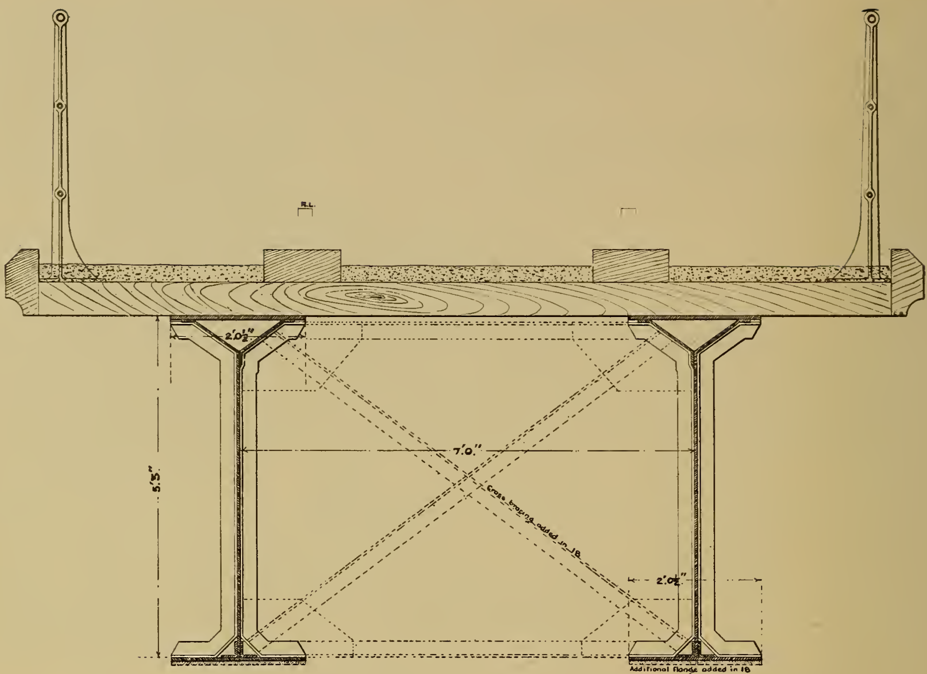



FIG. 14—SECTION OF BRIDGE OVER RIVER EDEN AT MUSGRAVE. SPANS 69 FEET. NOTE CELLULAR COMPRESSION FLANGES. SIR THOS. BOUCH, ENGINEER, 1862

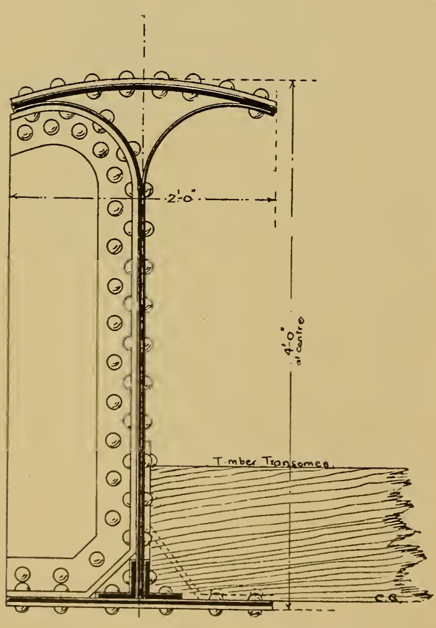



FIG. 13.—GIRDER FOR BRIDGE OVER STAINDROP ROAD, NEAR DARLINGTON. SPAN 53 FEET. SIR THOS. BOUCH ENGINEER, 1856

The compression flanges of wrought-iron girders were the cause of much nervousness, judging from the experiments made in different bridges. There were some engineers who still adhered to the use of cast iron for all compression members where possible. In 1853 a remarkable bridge was erected over Newark Dyke on the Great Northern Railway. This was a Warren girder having all the compression members of castings, and the tension members wrought-iron bars. There are no early examples of Warren or lattice girders on the North-Eastern Railway, owing to Mr. T. E. Harrison's objections to their use; but these girders at Newark were a very striking example of the combination of the two materials. They were over 250 feet long and 17 feet deep, and the four weighed nearly 500 tons together, exclusive of the flooring. They do not compare at all favourably with tubular girders of the same span, as

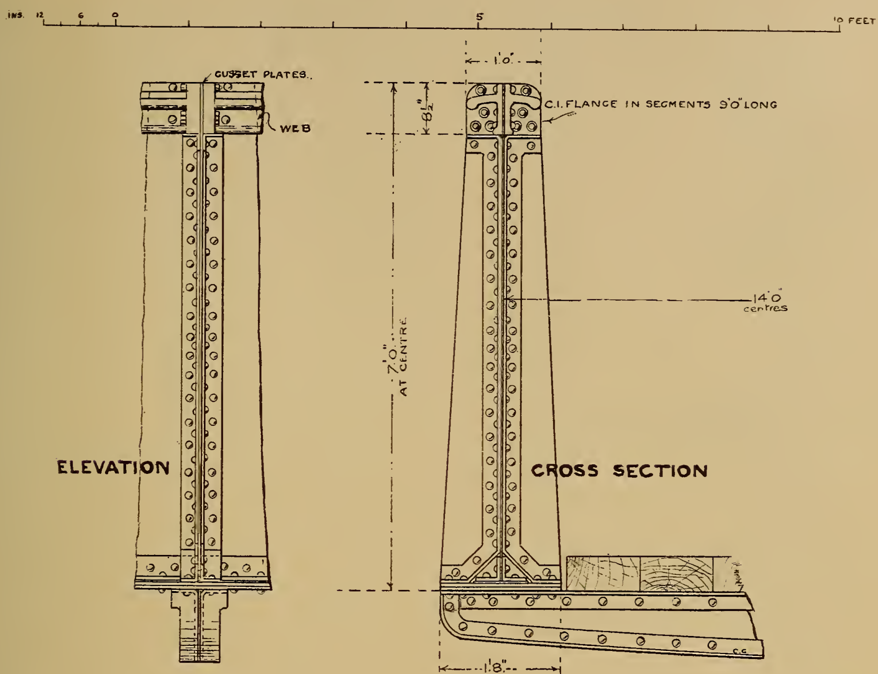



FIG. 15.—GIRDERS OVER RIVER NIDD AT POTELEY BRIDGE, YORKSHIRE. SPAN 96 FEET. T. E. HARRISON, ENGINEER, 1862

to weight, owing to the massive nature of the cast-iron portions. They were removed many years ago and modern braced girders took their place.

As late as 1862 wrought-iron plate girders with cruciform cast-iron top flanges were made. Mr. T. E. Harrison employed this type of girder on the Nidd Valley, Lanchester Valley, North Yorkshire & Cleveland and Whitby branches. Some of these girders were 100 feet in length, and they were all hog-backed in form.

The cast-iron flanges were bolted to the web plates and to the gusset plates, and were carried down to the bearings at the end of the girders. There is something of the nature of the tied arch in these bridges, and seems to indicate a distrust of the simple plate-girder type with flat flanges. That the girders were assumed to act as simple girders and not as arches is suggested by the written calculations for the tensional flange area which are found on the drawings; but it may be that the heavy castings were expected to behave as arch ribs, and the tension flange was considered as a tie to act in place of the solid abutment. A great fault with these girders was the narrowness of the upper flanges. Whereas the tension flanges of flat plates were about 2 feet wide, the compression flanges were about 12 or 15 inches only, and, as may be expected, they were inclined to buckle and fail at the joints. It is strange that the narrowness of these cast flanges was not considered an insuperable objection to their use, and that plain wrought-iron plates were not substituted. It appears that the whole benefit of using the material strong in compression is more than counteracted by the method of its employment.

The illustration (Fig. 15) shows girders removed from the Nidd Valley branch a few years ago and replaced by modern steel girders.

These are the last examples showing cast iron employed in combina-

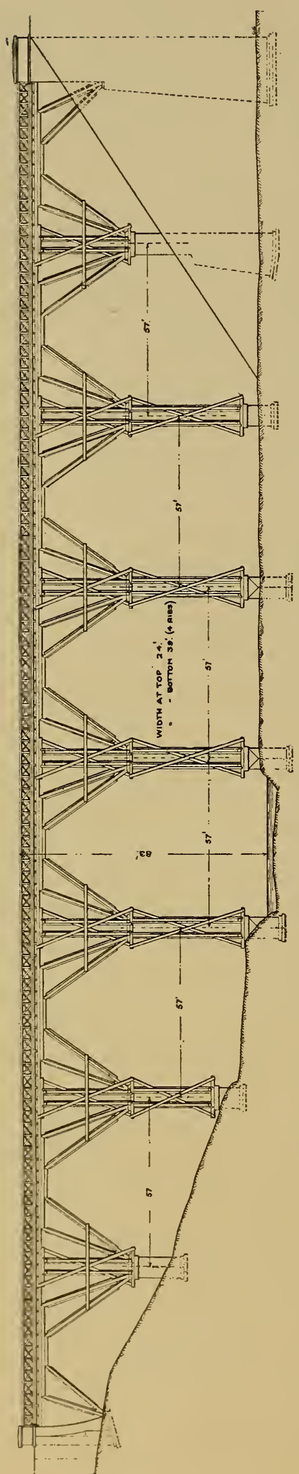



FIG. 16.—TIMBER VIADUCT OVER RIVER DEARNESS. YORK, NEWCASTLE & BERWICK RAILWAY T. E. HARRISON, 1857

tion with wrought iron in girder work. It was, and is, used to a considerable extent in the columns of bridges and in bearing plates for girders and in the mechanical portions of movable bridges. It was about this time (1860) recognized that, though much stronger in compression than wrought iron, its disadvantages outweighed the mere advantage of strength, and that plate girders made entirely of wrought iron were far more successful than any composite structure. The very substantial plate girders on the York, Selby & Doncaster branch, made in 1868, were entirely of wrought iron, and showed that between the years 1861 and 1868 the use of cast-iron compression flanges was discontinued. In fact, the original contract drawings for bridges on the Whitby deviation branch made in 1863 show combined girders, whereas some of these bridges were built with simple wrought-iron girders, new drawings being made while the works were in progress. The date of the change is, therefore, exactly ascertained.

To go back a few years, to 1857, some large viaducts of timber were built by Mr. Harrison, of what was known as the fan type, invented by Brunel, and used largely by him in lines in the West of England. These were built on the Auckland branch of the Great North of England Railway, which, in 1854, formed part of the North-Eastern Railway in the great amalgamation. The viaduct illustrated in Fig. 16 is certainly of a very different type from most of the bridge work designed by Mr. T. E. Harrison, but it was inexpensive and speedily erected. The bridge was built of whole timbers braced with half timbers, on masonry footings. It is not typical of most of the bridge-building in this country, and most of these timber bridges have been replaced with brick arches. The Dearness viaduct was so rebuilt in 1900 by Mr. C. A. Harrison. There are some timber bridges still in existence, however, on the old

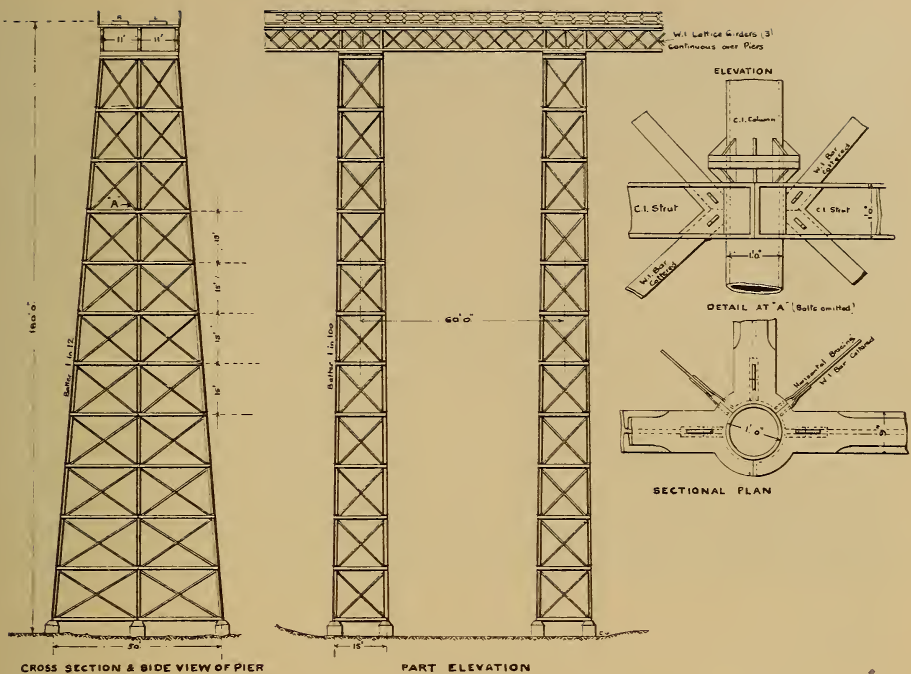



FIG. 17.—BELAH VIADUCT, 16 SPANS OF 60 FEET. SIR THOS. BOUCH, ENGINEER, 1861

Blyth & Tyne Railway, where pitfalls, due to colliery workings, are of fairly usual occurrence. A timber bridge is most suitable in such a situation, since its weight is small, and it is not ruined by a subsidence of the foundations, which would cause a brick viaduct to totally collapse.

Speed was a very important factor in deciding what materials should be employed for the high and long viaducts, of which there are so many in this district. An interesting discussion on the relative advantages of masonry or brickwork and of ironwork for such structures took place on the occasion of the reading of a paper by the late Mr. Wm. Cudworth before the Institution of Civil Engineers in 1862. The subject of this paper was the Hownes' Gill Viaduct on the Stockton & Darlington Railway near Consett, this work being carried out entirely in firebrick. The result was an extremely pleasing structure, consisting of a dozen semi-circular arches of 50 feet span, the greatest height being 150 feet. The piers are lightened as much as possible (and to an unusual extent) by cavities and relieving arches; but when Mr. Cudworth compared this viaduct with those just erected by Mr. Thomas Bouch on the South Durham & Lancashire Union Railway, of ironwork entirely, he found that the brick structure was about 25 per cent. more expensive than one of the same size in metal. The iron viaducts were built extremely rapidly, and Mr. Bouch stated that the ironwork of the Belah viaduct of sixteen spans, each of 60 feet, and of a height of nearly 200 feet, was erected entirely in four months. This is an almost incredibly short time to complete such a work, and the progress must have been at the rate of one complete span per week. The reason for the great speed was that the completion of the line awaited the building of the viaducts, as large quantities of excavation had to be conveyed across the deep ravines.

Fig. 17 shows the construction of the viaducts on this cross-country

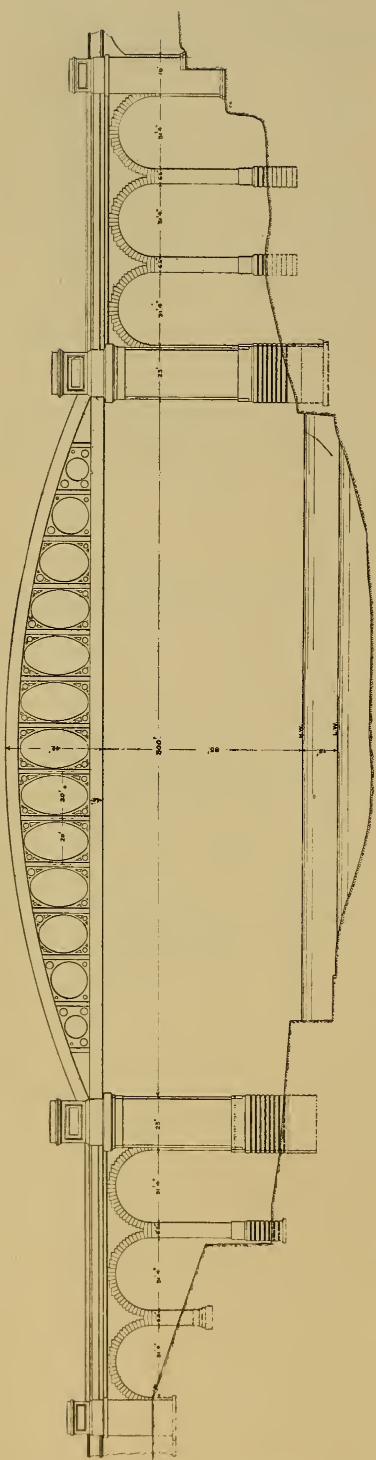


FIG. 18.—BRIDGE OVER RIVER WEAR AT SUNDERLAND. WROUGHT IRON GIRDERS. 300 FEET SPAN. T. E. HARRISON, ENGINEER 1879

line over the Pennines by Stainmoor Pass. The columns are built up of cast-iron pipe sections, and strongly braced in all directions. In spite of the very short time taken in erection, all the ironwork was carefully fitted together, and it was stated in the discussion at the Institution already referred to that the workmanship and quality of material had never been surpassed. The girders themselves were of the lattice type, and are three in number, carrying a double line of way. These have been strengthened to permit of heavier rolling stock, and this work was carried out by Mr. W. J. Cudworth in 1898. A very heavy mineral traffic is carried over this line, which is, by-the-by, one of the most beautiful in situation in the country. No idea of the appearance of these lofty viaducts can be obtained from the railway train, but the view from below is most striking.

Mr. T. E. Harrison, for many years chief engineer of the North-Eastern Railway and of the earlier lines, was responsible for many bridges of considerable span which would now almost certainly be constructed with some kind of braced, open-web girder; but all his girders, with one notable exception, were plate girders—that is, after the disappearance of cast iron on a large scale.

There are a good many plate girders of as much as 130 feet span, and one—the Goole Swing Bridge—of 250 feet over all. The exception to this rule of using plate girders is the great bridge at Sunderland (1879), which adjoins the old arch of Burdon and Stephenson (Figs. 18 and 19). The girders are 310 feet long and 42 feet deep at the center. The design is quite unique and rather difficult to describe. They are not plate girders, and though it may be called an open-webbed girder, it cannot be treated as an ordinary braced girder, since there are no diagonal members. The probability is that it was intended to be a tied

FIG. 19—SUNDERLAND BRIDGE OVER THE WEAR. THE OLD ARCH BRIDGE OF BURDON AND STEPHENSON IS SEEN IN THE BACKGROUND

arch, and it may be treated as a similar case to Stephenson's cast-iron arches at Newcastle. The webs between the vertical ties will, of course, stiffen the arch rib against distortion under unsymmetrical loading. The upper and lower booms are box-shaped, 5 feet 6 inches deep and 2 feet 6 inches wide, and the cross girders are attached to the lower boom, which is a very stiff girder in itself. If the webs were of a very much more substantial nature than is the case they would, perhaps, make the girder a kind of plate girder with pierced webs; but they are not sufficiently developed to permit of the girder being so considered. The bridge was drawn to Mr. Harrison's designs, and it is said that his assistant, to whom he entrusted the work, was not altogether pleased with his test and would have preferred a very different type of girder, and he never quite made up his mind how to describe it when it was finished. If the Wear bridge had had parallel booms, it would probably have been an impossible structure, owing to the lack of proper diagonal members, and its stability would have depended on the light, pierced webs to a much greater extent than is the case. The bridge gave very little deflection under two trains of heavy engines when it was tested before opening for traffic, and it has been proved to be a perfectly substantial and satisfactory bridge.

Several bridges built at different places on the North-Eastern system were carried on cast-iron cylinders sunk in the bed of the rivers and filled with brickwork and concrete. This was a very favourite design, and in most cases the superstructure consisted of hog-backed plate girders. The bridges on the Selby & York and Selby & Doncaster branches over the rivers and canals, and the bridge over the Tees at Thornaby, built in 1881 to carry an additional pair of lines for mineral traffic, were of this type. The latter was designed and erected by Mr. W. J. Cudworth, acting as assistant to his father, the late Mr. Wm. Cudworth, and in this case lattice girders would have been employed had it not been for the expressed wish of Mr. T. E. Harri-

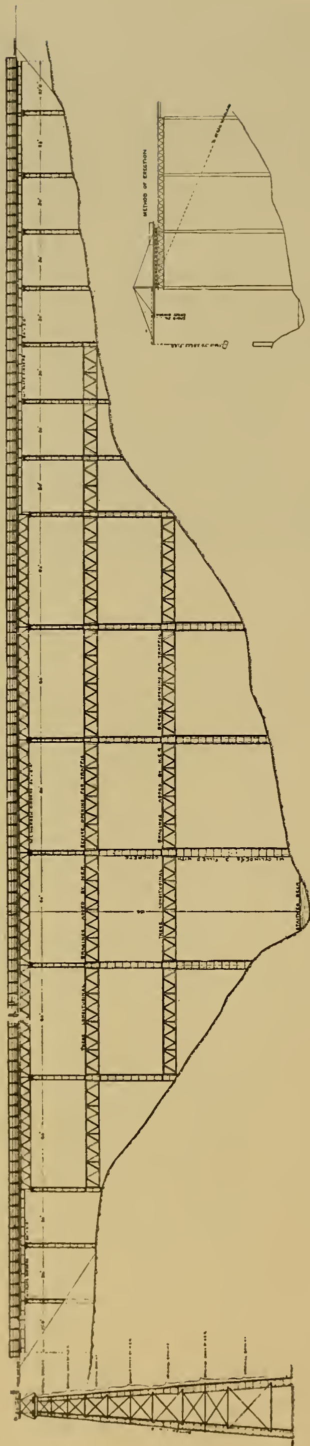


FIG. 20.—STAITHES VIADUCT. DESIGNED BY J. DIXON. STRENGTHENED WITH LOWER GIRDERS BY T. E. HARRISON, 1883

son, who retained supervision of the engineering work on the lines formerly forming the Stockton & Darlington Railway, that plate girders should be used. This was the third bridge erected at this site, and forms a useful comparison with the adjoining bridge of Robt. Stephenson.

Twenty-one years after Sir Thos. Bouch built his lofty viaducts over the Belah and Deepvale ravines five rather similar bridges were opened for traffic on the Whitby & Loftus Railway. These had been built some years before, and were considerably altered by Mr. T. E. Harrison when the North-Eastern Railway took over the then derelict line. The largest one of the five—that at Staithes (Fig. 20)—is shown as an illustration, and is substantially different in some respects from the bridges of 1862, though its purpose and situation is very similar. Instead of cast-iron piers, wrought-iron cylinders filled with concrete were used. These were cheaper than castiron, which required such an amount of machining and fitting together, and the number of loose parts was much fewer. As at first built, there was very inadequate bracing to the columns, and all the longitudinal lattice bracings were added in 1883, before the line was opened under Board of Trade sanction. Where the deepest part of the ravine was crossed 60-foot spans were used, and at the ends 30-foot spans, the former being Warren girders and the latter plate webs. The erection of these bridges was carried on with practically no staging, by an arrangement indicated roughly in the illustration. The girders were, as usual, in this type of bridge continuous over the piers, and though this puts quite unknown stresses in the flanges, owing to the variation of level in the supports, it is, perhaps, the best arrangement in such bridges, as it increases the stability and rigidity of the structure considerably. Ample allowance must be made in the design of the girders for varying conditions of stress, how-

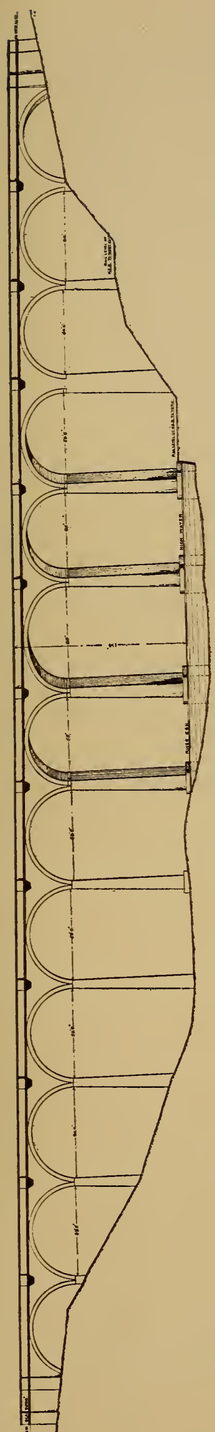


FIG 21.—VIADUCT OVER RIVER ESK AT WHITBY. BRICK ARCHES AND PIERS. SIR CHARLES FOX & SONS, ENGINEERS, 1884

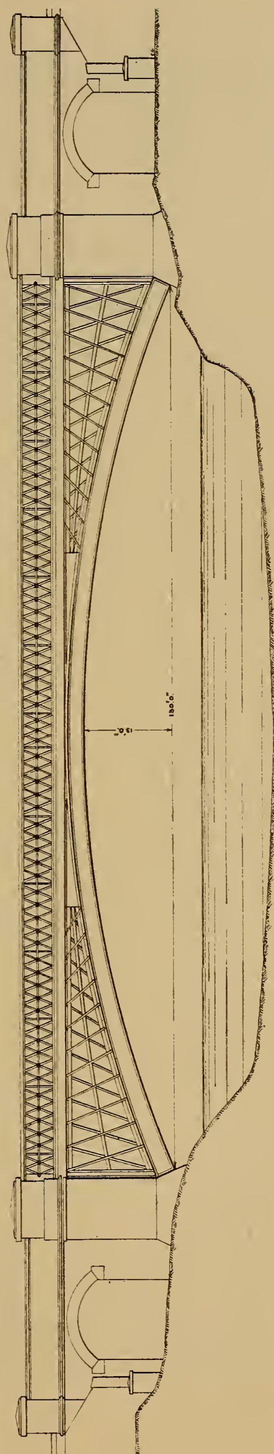


FIG. 22.—WROUGHT-IRON ARCH OVER RIVER WEAR BETWEEN SHERBURN HOUSE AND DURHAM ELVET, C. A HARRISON ENGINEER, 1892

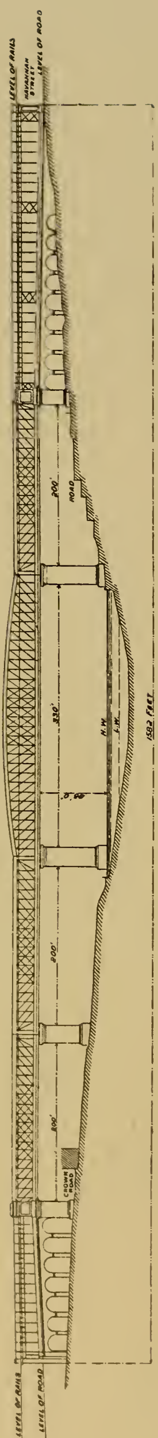


FIG. 24.—RAILWAY AND ROAD BRIDGE OVER RIVER WEAR AT SUNDERLAND. C. A. HARRISON, ENGINEER

ever, and room for expansion must be left at each end on the abutments.

Shortly after the Whitby & Loftus branch gave communication along the Yorkshire coast from Whitby to Saltburn and Middlesbrough, the Scarborough & Whitby Railway, opened in 1885, completed the coast route southwards. This line includes a fine brick viaduct (Fig. 21) over the river Esk at Whitby, which every visitor to this beautiful old port knows well. It is in the strongest possible contrast with the iron viaducts on the northern branch, and with them forms as interesting comparison as that made by Mr. Wm. Cudworth between the Hownes Gill Viaduct and the Belah and Deepdale viaducts. There is not much difference in the general appearance of this brickwork structure and that of many such bridges built years before, but it may be taken as a typical case of the best modern work.

The last wrought-iron bridge described in this article was built at the exact time when steel began to supersede the older material. 1892-3 marks the transition from the one to the other on the North-Eastern Railway, and this bridge, shown in Fig. 22, which is an arch over the river Wear near Durham, was one of the last built in iron. This bridge was designed and built by Mr. C. A. Harrison, who had been appointed engineer of the Northern division of the North-Eastern Railway on the retirement of his uncle, Mr. Alfred Harrison, in 1888, which occurred at about the same time as the death of Mr. T. E. Harrison, who retained the control of the engineering on the whole system until the end of his life. It is worthy of note that Mr. T. E. Harrison, who built the Victoria bridge over the river Wear in 1836-8, was engaged in building bridges, among other engineering work, until 1888, and though he did not see the introduction of steel girders, he certainly had better opportunities than any other engineer of his time of following the progress

FIG. 23.—KING EDWARD BRIDGE, NEWCASTLE-ON-TYNE. MID SPANS 300 FEET. SHORE SPANS 231 AND 195 FEET. CARRIES FOUR LINES OF RAILWAY.
C. A. HARRISON, D. SC., ENGINEER, 1906

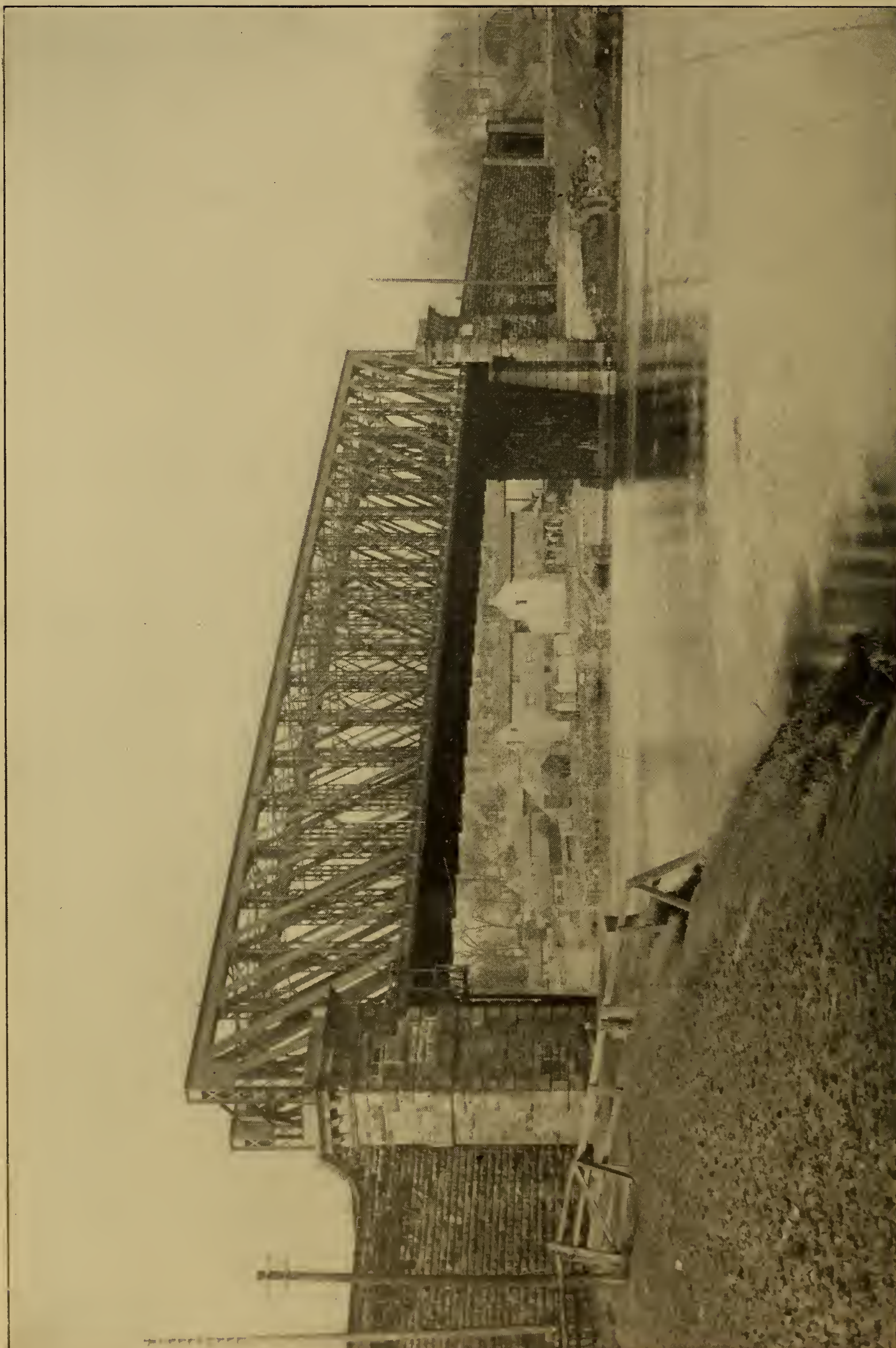


FIG. 25.—BROTHERTON BRIDGE OVER RIVER AIRE W. I. CUDWORTH, ENGINEER

of bridge design and the development of girder building.

The great bridges which in recent years have been built in steel work are so well known and are of such varying types that it would be impossible adequately to describe them here. The two greatest works on the North-Eastern Railway, which serve as good illustrations, are those over the Tyne and Wear.

The King Edward bridge over the Tyne at Newcastle is an interesting comparison with the old High Level bridge. The girders are of the lattice type, of a span of 300 feet, and many costly river piers are avoided by the employment of such long girders, which were not possible in cast iron when the old bridge was built nearly sixty years before. This bridge was opened by the King in 1906, and as it is built for four lines of way, and provides a through line from the south to the north, avoiding a change of direction at the Central Station, Newcastle, it is well worth its great cost.

The new bridge over the Wear at Sunderland is now in course of construction, and is even a greater work than the Tyne bridge. It carries two lines of railway, a carriage-way and two footways, and is, therefore, rather similar in its capacity to the old High Level bridge over the Tyne. The centre span at the time of writing is still to be erected, and this will complete the work. Whereas in building the old Wear bridge Mr. T. E. Harrison was allowed to construct a timber staging to carry the girders in course of construction, in the present work no staging is being employed for the centre span, which will be erected, piece by pice, from both ends on the cantilever principle. A great steel derrick, 100 feet high, is to be erected on each river pier, and this will support the portions until the centre part unites the two and completes the girder.

Both these bridges, the King Edward and the Sunderland bridge, have been designed and carried out

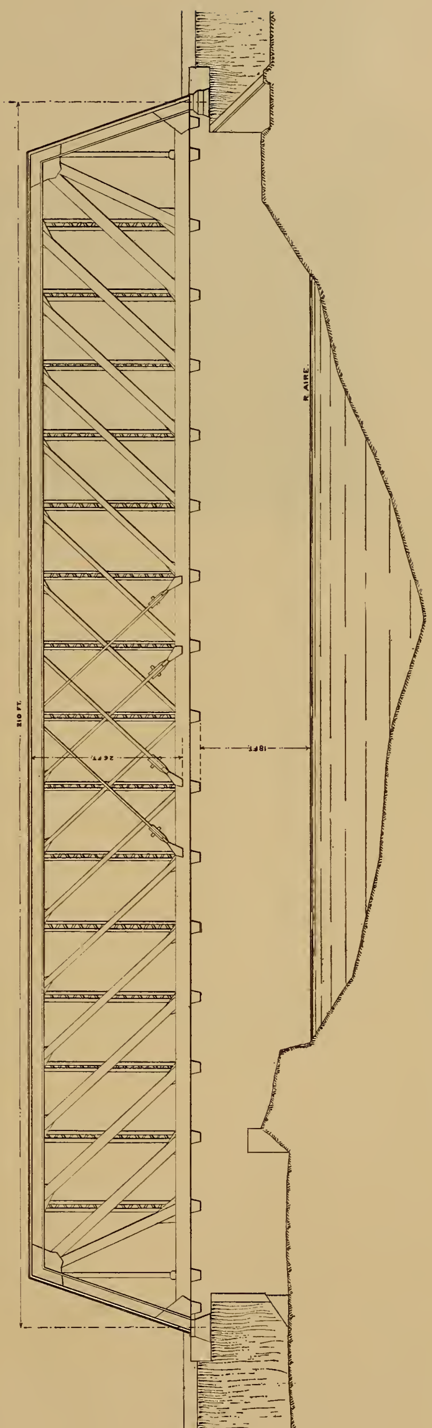


FIG. 26.—BRIDGE OVER RIVER AIRE, SELBY & GOOLE RAILWAY. W. J. CUDWORTH ENGINEER

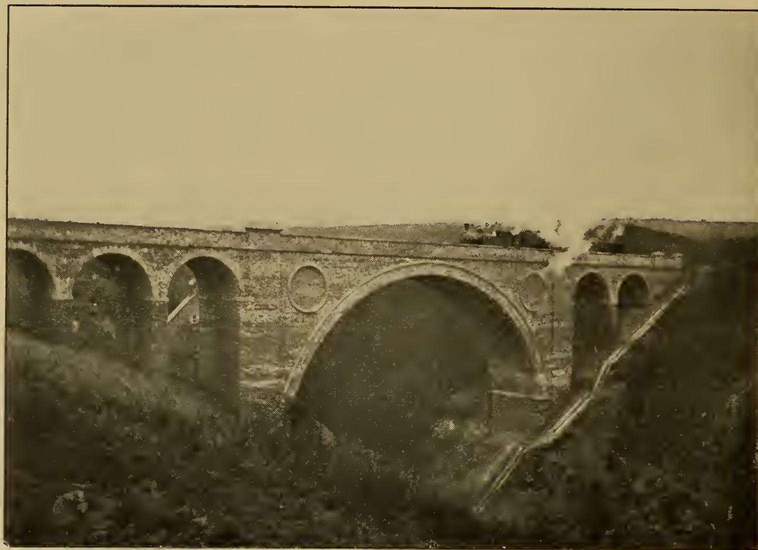


FIG. 27.—HAWTHORN VIADUCT, SEAHAM & HARTLEPOOL BRANCH OF NORTH EASTERN RAILWAY. BRICK ARCH 120 FEET SPAN

by Charles A. Harrison, D.Sc., of Newcastle.

Other examples of modern girders are those over the river Aire at Brotherton, which replaced Robt. Stephenson's most inconvenient tubes, and the new bridge in course of construction over the same river near Drax on the line of the new Selby & Goole Railway. These are both Whipple-Murphy girders similar to the new Sunderland bridge, and are both over 200 feet in span. They are built to the designs of Mr. W. J. Cudworth, of York.

The principal changes which have taken place in the design of steel work in late years have been due to the greatly increased variety and suitability of sectional steel provided by the rolling mills for use in the bridge yard. In early rivetted structures the rivets themselves were often few in number, and were put in more to suit the eye or the fancy of the foreman than to follow any very scientific rule. Nowadays the rivetting is designed as carefully and as closely as any other part of the bridge, and if the number of rivets is often not greatly in excess of that found in early girder work, the reason is that sections rolled complete in themselves take the place of built-up members to a great extent. The standardization of sectional steel has led to the sorting out of the really useful sections for all kinds of structural work, and will lead to the abandonment of those not frequently required; but the variety of joints, channels, angles and tees available is very great, and selection should be made from such standard sections, if economical design is an object.

Rolled joists or beams are much more scientifically designed than formerly, and proper amount of metal is put in the flanges. Special sections are designed for use as struts, and many great steelwork firms issue handbooks showing simple and compound girders and struts suitable for every possible span and load, rendering the design of many kinds of work a much easier and quicker operation than formerly.

Not very much has been done in Great Britain towards the standardizing of bridges, and great diversity of detail can be observed, not only between bridges on different railways,

but also between bridges on the same line. The conditions affecting the design of bridges vary so greatly in the cases which come to be dealt with from time to time that it is hard to adhere to any standards for long. A good deal more might, however, be done in this direction, and it is of the utmost importance, with a view to economy, that where alternative methods are equally, or nearly equally, as good, the more usual one should be adopted, and that in any one structure the number of sections employed should be as small as possible, and that no unusual section requiring special rolling should ever be specified except in a large quantity—at least 100 tons—or where no other can possibly be substituted. With any system of standardization, however, enough elasticity must be allowed to give scope for improvement as new methods of manufacture or new ideas of construction are discovered, and it must be, in any case, rational standardization and not stagnation.

The beautiful brick arch shown in the last illustration is on the Durham Coastline, opened in 1906, and shows what can be done in brickwork under suitable conditions. Like all brick or masonry bridges, there is nothing strikingly new about the design, though the span, 120 feet, is great. A girder bridge in such a situation as this would have been a great mistake, aesthetically and practically, as any saving in first cost would be counteracted by future expense in renewing and maintaining. Where the railway is carried at such a height above the ravine as in this instance semi-circular arches can be employed with very fine effect.

# THE ENGINEER AS A PURCHASING AGENT

By James M. Cremer

IN many manufacturing and engineering works the purchasing department is considered as belonging wholly to the business administration of the establishment, and hence placed in charge of a superintendent whose qualifications are almost entirely of a clerical order. With the entrance of the engineer into other departments of shop administration, however, it has been thought advisable to consider to what extent engineering methods can be applied to the increase of the efficiency of the purchasing department.

In order to show the extent to which technical matters really do enter into the advantageous purchase of engineering supplies, the writer believes that a description of the results of a change from clerical to engineering supervision, as of actual occurrence in a large establishment in the vicinity of New York City, will throw light upon an important department of successful manufacturing. The department of purchases and stores of this establishment was turned over to a mechanical engineer, as its chief, and the difference between the state of affairs as he found it and as modified in accordance with engineering experience will be found instructive.

The administration of the storeroom, which in reality was a large, specially constructed building devoted to that purpose, was placed in charge of the purchasing agent, in so far as it related to requesting the quantities of various goods, materials and supplies carried there in stock, so as to keep the amount of money invested in stores within reasonable and proper limits, and also to so systematize the methods as to reduce the clerical and other labour involved in making out orders and receiving and checking up goods to a minimum.

As a first step in that direction a large number of lists of the standard materials and supplies of various kinds were made up, showing the quantities of each, by size or other designations, that had been used in the past year or two, as taken from the record books of orders, so as to determine the probable average quantities per year and per month for the current year. These quantities were then used as a basis for ordering goods, the intention being, in general, to place the orders for standard articles regularly every month and to carry no more in stock than a supply sufficient for a month or six weeks, or, possibly, even two months, in cases where the deliveries were more or less uncertain.

Formerly standard supplies had been ordered from day to day, as any particular size or kind of goods might run low, and it frequently happened that small lots of different sizes of things would be ordered on several successive days, instead of all the sizes regularly used at the one time. This could evidently have been accomplished if an order covering a full line of sizes for a month's supply had been given early in the month, as was the case when this custom was afterwards inaugurated. The change resulted in fewer orders, less labour in receiving, weighing up or counting

up the goods, checking bills, and, incidentally, what was very important, the practice of periodically going over the stock to verify the monthly requirements, called attention regularly to its condition and rendered it more unlikely to ever run out, especially with the margin of reserve allowed, which covered any irregularity in the consumption or any delay likely to occur in filling the orders or in transit. This regular and systematic ordering of standard goods and materials, so far as to conform to the average quantities required per month which was thus made possible, not only greatly reduced the clerical and other labour involved, but it eliminated many hurry orders that might otherwise have been inevitable through oversight in ordering, and it was thereby a great relief to all concerned. Hurry orders have no legitimate place in any well-regulated storeroom or factory, and are always to be deprecated.

In addition to the general stores and materials directly needed in the manufacture of the various lines of light and heavy machinery comprising their product, the works consumed large quantities of other materials and supplies in great variety for operating large iron and brass foundries, blacksmith shops, machine shops, pattern shops, carpenter shops, sheet metal shops, testing shops, boiler house, and the power and electric lighting and electric power plants. The requirements, therefore, included coal of several different kinds, coke, pig-iron, moulding sands and loam, foundry facings, flour, acids for pickling, fire brick and fire clay, shovels, sieves and other tools, also copper, tin, spelter, lead, phosphor tin, composition and other metals, bar iron, machinery steel, cold-rolled steel, tool steel of several grades, including high-speed steel, rolled shapes for structural work, heavy, rough and finished forgings of many kinds, such as crankshafts, piston rods, connecting-rods, drop forgings in great variety, large lines of malleable iron, gun iron and steel castings, brass castings for standard or special work, and large quantities of lumber for pattern and carpenter shops, the latter mainly for boxing or construction work. Also the storeroom carried, in connection with the ordinary and usual supplies, either directly in that building or elsewhere under its oversight and control, a large line of heavy general supplies and materials, such as wrought iron and brass pipe and fittings for steam, water or air, brass and iron valves and cocks, water columns, steam, water and air gauges, steam and water packings of many kinds, rubber goods, including a large line of rubber valves for various kinds of duty, drop forgings, malleable iron castings, steel castings, brass castings, including brass piston rods, sheet brass and brass wire, and numerous other goods and small tools, such as files, twist drills, hammers, etc., in great variety.

Now keeping in mind the desirability of obtaining accurate information as to the average quantities of all the foregoing and similar materials that were being used per year and per month, the records were carefully gone over for that purpose as rapidly as time permitted. Naturally, a beginning was made with such large items as pig-iron, copper, tin, composition metal, coal, coke, moulding sand, lumber, and the like. Then, in course of time, the work was extended so as to include practically all of the others of any importance. Once this was accomplished and the average quantities kept revised from time to time as the business might vary for any reason, this accurate information regarding the average quantities of materials consumed was simply invaluable as a basis for making out orders, whether monthly or at any other intervals. Its great value was not only in reducing merely clerical and other routine work to a minimum, but because it gave to the purchasing agent a grasp of the whole situation that

could hardly have been possible without such an aid. It enabled him to act quickly, so as to take advantage of favourable conditions in the market and place the order intelligently, and also to be able to obtain at other times closer prices, when asking for quotations, by naming good-sized, round lots of material that were attractive to the trade. Sometimes, also, a dullness in certain lines occasioned concessions in prices that permitted placing of orders ahead of current requirements, the goods to be made up and held in readiness for shipment when wanted, no payment being expected until then.

Sometimes this course was adopted simply for the sake of having a supply of some standard goods ready for instant shipment, thus guarding against any delay where this might be an unusually serious matter in the case of urgent orders. This ability to bunch the orders, which an accurate knowledge of the shop requirements permitted, was uniformly successful in securing lower prices. In some lines, if desired, prices would be named to hold good for an entire year, with protection against any decline in prices, the orders to be sent in as the goods were needed, the expectation being that certain amounts would be called for during the year, although this was not rigidly adhered to, nor was it all necessary.

For obvious reasons it is not well to carry all of one's eggs in the same basket and, therefore, in placing orders for certain important kinds of goods and materials, it was considered advisable not to have the total quantity wanted go to any one concern, but to divide it up among several concerns, and, preferably, those in different parts of the country, so that due protection would be afforded in case of strikes or shutdowns from any cause, or from delays in transportation by reason of similar causes. This division of the orders, however, adopted simply as a measure of safety, still gave such substantial ones to each that it did not practically affect the various prices unfavourably.

In general, the requisitions for materials originated in the storeroom, covering what goods were needed there for stock, or were issued by the foremen of the various shops, or the general foreman, or the heads of departments, including the engineering department and the erecting departments. The latter requisitions called for such goods and materials as were wanted in the construction of various engines and other machinery under way in the shops or being erected at destination. Requisitions from the storeroom were written on a printed form of standard letter head or folio size by the storekeeper, made out daily and submitted by him to the purchasing agent, giving a list of all articles and materials to be purchased at that time. These, ordinarily, included regular storeroom supplies for replenishing stock, and also a considerable quantity of other goods and materials called for on the requisitions from the various foremen. These latter requisitions, as a matter of routine, were handed in first to the storekeeper, to be filled from his stock, if regular, or ordered specially through the purchasing agent if not such as were kept on hand. Generally the foremen's requisitions, which were written on a smaller printed form having a stub that they retained for their own record, were handed in with the storeroom requisition sheets, so that any important particulars or dimensions thereon might be verified by the purchasing agent when making out his orders for the materials and goods. In many cases similar requisitions for special work or materials needed in construction would come direct to the purchasing agent from the drawing room, the engineering department or the erecting department, and would then always be accompanied with drawings, sketches, specifications or such other full data as were needed in making out the orders. All requisitions mentioned the proper order number or account to which the ma-

terial was to be charged. As all work being constructed in the shops, whether on regular orders or stock orders, was designated by appropriate numbers and these were named in the requisitions, and as the purchasing agent had on file copies of all the important orders, he was able to ascertain whether or not the various requisitions handed in were regular and proper ones without the formality of first submitting them to the superintendent for approval, which, in fact, was seldom, if ever, required, the foremen's and other requisitions being recognized as sufficient authority.

The storeroom requisition sheets, of folio size, were printed and ruled so as to provide space for date and suitable columns with the following headings: Description of goods, name of concern where ordered, order number, accounts charged. On these sheets, under the proper date, all needed particulars concerning the goods to be ordered were entered by the storekeeper, the names of the concerns where the orders were to be placed and the order numbers, however, being left blank for the purchasing agent or his office to fill in. After inspecting these sheets, filling in the blanks, as noted, and satisfying himself that the purchases were all proper ones and duly authorized, as shown by the foremen's or other similar and signed vouchers, as mentioned, the orders were then made out by the purchasing agent, or under his direction, and submitted to the superintendent for his approval, and then were signed, issued and recorded.

As the items of goods in the various orders needed only a very brief description when entering them in the record book, the amount of daily labour involved was very moderate for so large a volume of business as was transacted; and by means of this book the storekeeper and also the receiving clerk were able to know at all times what goods had been ordered in the various lines and to answer inquiries from foremen and others desiring information as to what goods had been ordered, and to ask the purchasing agent to hurry them along when overdue and required for urgent work in the shops, or when needed by the storeroom or any other department.

Whenever goods were delivered at the works on regular orders from the purchasing agent the fact was at once known at the storeroom, or reported to them, and the receiving clerk stationed there was able to quickly locate the goods and their destination, either of his own knowledge by the character of the goods or by reference to the indexed record book. If such goods or materials were intended for storeroom stock they were retained there; if intended for certain orders going through the works, and not wanted immediately, they were carefully tagged with the proper order or engine number and held at the storeroom in readiness for shipment when called for. Other goods would be sent directly to the shops or departments where they belonged, the weights or counts being taken when the goods arrived and entry made of all of them in the record book of receipts of material.

Daily returns of these receipts of materials and goods were made out on suitably printed and ruled forms of the same size as the requisition sheets, and of similar but distinctive style, and handed in every morning to the purchasing agent, thus reporting to him what goods had arrived the previous day, all being designated by the proper order numbers. These returns were then copied into a substantial record book, kept in the office of the purchasing agent, by one of his assistants, and the bills for materials and goods were checked up by this book and also by the large record book of orders.

The record book of receipts of materials, therefore, afforded a ready means for noting in the proper column the fact that a bill of a certain date, corresponding to each shipment or delivery of goods, as shown by

the receipts of goods on account of the appropriate order number, had been checked, or else that no such bill had yet been received in any given case. It also was found to be a reliable check to guard against approving any duplicate bills that might otherwise pass through unnoticed.

The bills for materials were not allowed to go to the storeroom, either with or without the prices, as, for obvious reasons, it was not considered proper to have the prices known outside of the office of the purchasing agent and the general office. Also, by having the daily returns of receipts of goods and materials made out without any reference to the corresponding bills, it introduced a check upon the accuracy of the returns themselves, as well as that of the bills, which had a wholesome effect and tended to eliminate errors. Also, by particularly requesting on the order forms that bills be promptly rendered, which was almost uniformly complied with, discrepancies were the more easily detected and adjusted. The requirement of promptness was, besides, a great time-saver in every way.

All bills, as regards correctness of the prices, receipt of goods in proper quantity and of satisfactory quality, as well as noting thereon the proper account to be charged, were checked up in the office of the purchasing agent, and his autograph initials on the bills indicated such facts to the superintendent of the works, who also noting that extensions and footings had been gone over in the general office and passed upon, thereupon approved the bills for payment, which was made monthly at a fixed date, except in special cases, or where cash discounts for early payments were allowed.

The general office was able to get all needed information from the bills as marked to serve their purpose for cost-keeping and for any other accounts that were kept up.

To facilitate the clerical work connected with the business, there was kept in the office of the purchasing agent a large record book of orders similar to that already mentioned as being used in the storeroom. This book was adopted as embodying the simplest and best practicable method of keeping track of the large number of orders and corresponding bills incident to the business. The book, however, was ruled with two additional columns, headed "Price" and "Date of Bill," respectively, these columns not being needed for the storeroom record, because the bills did not go there to be checked up for prices or receipt of goods, nor were the prices known there, because the storeroom requisition sheets only—which made no mention of prices—were used for posting up the items of the serially-numbered orders. The duplicate stubs, or carbon copies, of the orders themselves were always held on file in the office of the purchasing agent. The large record books of orders referred to were found very convenient for the purpose, and it required but little labour comparatively to keep them posted right up to date. As a continuous record of all the important prices alone extending back for several years these books were invaluable, and they were also of much service in quickly determining the yearly and monthly average quantities of the various goods and materials used during any year of record as a basis to forecast the needs of the coming year.

Whenever any goods or materials were returned to a manufacturer or dealer for credit because defective, or for any other just reasons, they were immediately charged back to that concern and a bill was mailed to them, at the price originally charged. A memorandum bill of this charge was then passed through the purchase account in the regular routine, and it greatly simplified keeping track of such goods, avoiding possible oversight much better than to depend upon a credit memorandum.

In keeping track of the prices and

quotations, the purchasing agent used large, indexed memorandum books, leather-bound. These lasted a long while when concisely written, with all the abbreviations that are practicable, and were found very convenient. Needless to say, the purchasing agent kept up these books himself, personally, by the exercise of a little extra industry and self-denial, and hence they were always ready for instant reference when wanted.

Trade catalogues were kept on file in a large, specially-made cabinet, having some twenty-four drawers, or cases, adapted to a suitable classification, the catalogues being classified according to names of goods. The drawers or cases were numbered consecutively. A memorandum of the classification adopted was kept in one of the drawers and served to locate any catalogue or book that was needed for reference. But besides these the purchasing agent and his assistants had in their desks, or otherwise close at hand, their own personal working complement of trade catalogues and price lists, with memoranda and trade discounts marked therein, for quick reference at any time, and these were continually in request.

The manufacturing concern in question had a large and rapidly-growing business. They were, in fact, leaders in their particular line, and to maintain that position it was necessary, among other things, to be continually on the alert for new and better materials of construction and more efficient appliances, so as to be always making improvements in the product. Careful and systematic study was, therefore, constantly given by the purchasing agent to the general qualities and characteristics, as well as to the prices, of all the materials used for their product, so as to take advantage of every circumstance in the direction of betterment. Great pains were taken always to select the best and most suitable material for the particular function or purpose that any part of the machinery had to perform, taking into account not only the quality and price of the material itself, but also what is of great importance in manufacturing, how well it worked, and how it stood the final test of actual service. Any change in material that, without sacrifice of quality or undue increase in price, would save machine work in the shop, was considered a distinct gain, as securing greater economy in manufacturing. For example, it was found that a soft, strong and tough cold-rolled steel for piston rods, free from seams and from any tendency to distort when turned up in the lathe, cost no more to supply than another similar steel made by a different process, but which thereby gave much trouble, because it ran out of true as soon as a cut was taken over it in the lathe. This distortion required as much time to correct as was needed for the machine work alone on the former material. The change was, therefore, made, thus securing, at a better price, a much better rod, and effecting an important saving in labour, besides.

By taking occasion to inspect the materials, not only when delivered, but afterwards when being worked up in the shops and to note its behaviour there when being machined or otherwise operated on, the purchasing agent was able, aided, as he was, by the co-operation of those interested in such results, to effect many other similar and valuable improvements. One of these—that related to price of the material alone—was, in the case of certain large piston rods that were then made of hammered steel, costing a high price on that account, but for which similar rolled bars, made of an open-hearth steel of first-class quality and a proper carbon, to insure good strength and toughness, were substituted, and the latter rods cost only about one-third as much as the forged ones. The material in the rolled rods worked well in the lathe, requiring but little stock for finishing, and they, as well as many others afterwards

used, were found perfectly satisfactory in service, not one of them ever having broken or given trouble in any way, so far as we ever knew.

To emphasize the necessity and importance of frequent inspection and testing of the materials used, the following example will serve: At one time trouble was encountered with the rubber valves used for pumping machinery doing heavy duty. Several makes of valves were then in use, all of them marked when new with the maker's name moulded thereon. Some of the defective valves that were returned for examination, however, were so badly damaged that the name was obliterated. Something had to be done at once to locate the fault and devise a remedy, so the purchasing agent requested the foreman in charge of the testing shop to test, by actual service in a large pump for a sufficiently lengthy run, under the proper pressure, several sets, comprising all the various makes of valves which we were then using. This test was at once conducted, and it served to show, beyond any question whatever, the particular make of valve that was defective, all the makes but one, and that known by name, having withstood the severe duty. Steps were then immediately taken to remedy the trouble and prevent any repetition of it. It was here no question of a letting-down in quality, due to lower price, that had led to the difficulty, as the defective valves cost just as much as the good ones did; but it was some while afterwards found out that the maker of the defective valves had attempted to increase his profits by using an inferior grade of rubber instead of first-class stock, and thus occasioned himself and others so much trouble by failure of the valves in service that it eventually cost him the whole business.

Practical tests, by subjecting samples of various kinds or makes of high-speed tool steel to actual service in the regular work being done on lathes and other machines in the shop, so as to determine their relative efficiency and endurance for the roughing cuts and also of other special grades of steel for finishing cuts, were made from time to time, with most satisfactory results in an increased output at lessened cost. And also a special grade of high-speed steel was made up into twist drills and taps, which developed in service a much greater endurance—about two to one—as compared with the steel ordinarily used for such tools; and it permitted of operating them at much higher speeds and constituted so distinct a gain in these two directions as to justify the increased cost of making the drills and taps, which naturally was more than in the case of ordinary steel. In fact, the value of high-speed steel was so well appreciated that it was used wherever possible for turning, boring, planing and any operations where milling, facing or boring heads with inserted cutters could be utilized for the roughing cuts. For the finishing cuts, the inserted cutters were made of a special high-grade tool steel that held its edge to a remarkable degree, and also permitted high speed to an unusual degree, as was determined by extended tests in comparison with other first-class steels. The same special steel was likewise found of great value for threading tools, because it held its edges and shape so well. The introduction of such excellent steels in shops where piece-work had been for some time in successful operation was an added stimulus to the workmen, who appreciated having the best facilities provided them for increasing their output, and were not slow to take advantage of it in augmenting their earnings.

In the matter of cylinder, engine and machinery oils, somewhat higher prices were being paid, and had been in the past, largely, it would seem, for the sake of the oil, which was well known; but still some little hesitation was felt about making any change without due investigation. The purchasing agent happened, however, to know of certain oils, that he

had used elsewhere and found very satisfactory, and the average cost was approximately only one-half that of the oils in question. But to avoid making any error, samples of the proposed oils were ordered and then subjected for some weeks to the very hardest service existing in the works, being confident that, if it withstood that test, it would certainly serve elsewhere. The result was so entirely satisfactory that the oil continued to be used during many years, and was confidently recommended, when desired, to others for any similar service. The quantity of oil used per month was such that the savings in oil by the change amounted to about $100, say $1,200 per year.

Another instance of a change made in a material to another kind, equally good for its purpose and much more important in the saving effected, was in the case of copper, of which large quantities were used for brass and bronze castings. It had been for some time thought possible that another good brand might be had of practically equal strength to that of Lake copper, which was then exclusively employed in the mixture, for all kinds of castings, only a small part of which needed any great textile strength, while for many purposes the metal had simply to resist wear and corrosion. For the latter service any good casting brand of copper might do quite as well as Lake copper. To determine the question of tensile strength, some sample test bars were made up, using several different kinds of mixtures, such as required for the ordinary purposes in actual service, but employing Lake copper for one set and several other brands, which it was proposed to substitute for Lake, for the other sets. The tests, carefully made by an expert in that line, who had no knowledge whatever of the composition nor of any other conditions, were practically so nearly identical that there could be no risk involved when substituting the proposed new brands for the Lake copper. The difference in price at that time was about one-half cent per pound. It was then decided also to use an ordinary casting brand of copper for making metal that merely had to resist corrosion and effect a saving thereby of about seven-eighths to one cent per pound. A year or so later the question was considered of using some old metals, such as that from connecting-rod brasses, engine bearings, and the like, for certain kinds of work. This had been the regular practice some years earlier, but on account of some injudicious selection of the metal it had occasioned trouble, and old metals had been entirely abandoned on that account; but, at the later date, the purchasing agent, who had investigated the matter, was able to buy regularly a certain excellent kind of all-ingot metal that was virtually copper and tin, and it ran very uniform in quality, as shown by the color and as tested by the file, as well as by the conclusive test of actual melting up and using it. This metal could then be obtained at a price that was about two and one-quarter cents less than the price of Lake copper, and it was thenceforth substituted for an equivalent amount of that copper. But this price did not represent all of the saving secured, because the ingot metal, practically bronze, saved using a certain equivalent amount of tin. The importance of these several changes in the brass foundry practice, which were effected by the ready and intelligent co-operation of the foremen of that department, resulted in a total saving, based on the qualities used and the market prices of the metals at the time referred to, that amounted to about $11,000 per year.

As regards the iron-foundry cupola practice, there were certain changes made there also by an intelligent study of the chemical analysis and other characteristics of the various brands of pig-irons used, and with the concurrence and co-operation of the foremen, to whom the object of so doing was explained, that finally resulted in securing a saving in the

average price of the pig-iron melted that amounted to rather more than one dollar per ton. Almost coincident with this change in the mixture—which was mainly in the direction of substituting irons of clear grain in the pig for the more open grain, but both, for any brand, being of nearly identical chemical analysis, and the use of Southern, high in silicon iron, to secure softness—it happened that there was also introduced a very good coke for melting the iron. It was of exceptional purity and freedom from sulphur, which assisted greatly in improving the iron and keeping it soft, which requirement was highly essential for the product manufactured. The saving of $1 per ton may not seem so much in itself; but when ten or twelve thousand tons are melted annually, it is well worth securing.

Another large item was lumber, in which a saving of about $5 per thousand feet was effected in the grade used for boxing alone, which for the quantity annually used amounted to $3,600 per year. This was accomplished by using a somewhat cheaper grade, perfectly satisfactory, however, for the work, and by buying it in larger quantities and at favourable times.

For the making of patterns there had formerly been used an extra fine grade of clear pine lumber, carefully selected, soft, and very dry. It was not really necessary to use so high a grade of lumber for this purpose, more especially since many large patterns might be used only a few times—some, perhaps, once or twice—and certainly for them all a cheaper grade of lumber was more appropriate. Such lumber was, therefore, hunted up, and as soon as possible substituted, at an average saving of about ten to fifteen dollars per thousand feet, say twelve dollars for all thicknesses, which figure for the quantity annually consumed represented a saving of about $2,100 per year.

It has been estimated that in other numerous lines the savings effected, in the case considered, would average about 20 per cent. over the prices formerly paid, when no systematic endeavor was made to lower them. Even calling the probable saving in any like case about 10 per cent., it would be well worth securing and justify having a capable purchasing agent to secure such a result. Where the purchase account amounts to, say, two hundred and fifty thousand or five hundred thousand dollars or one million dollars per year, even 10 per cent. would represent such handsome savings as twenty-five thousand, fifty thousand and one hundred thousand dollars per year, and these are surely enough to justify paying the very small fraction thereof that is usually considered ample for the salary of a thoroughly qualified purchasing agent.

The purchasing agent, as already mentioned, made a careful study of all the material used in manufacturing their product, and the heads of the various departments would frequently confer with him to get information about the qualities and merits of different kinds of materials, tools, machinery and supplies, such as were obtainable in the market, in order to determine what it would be advisable to use for certain specific purposes as they might develop in the course of business. He had a file in his office, a large collection of trade catalogues and circulars, for ready reference when required, also photographs of machinery, tools and appliances of many kinds, and a cabinet of samples of various materials and supplies, that served to give anyone a very good idea of what was available or to suggest something adapted to the purpose in mind. Also, by reason of the fact, as already mentioned, that so many new things were constantly brought to the attention of the purchasing agent for investigation and possible adoption, while others of merit would be heard of and inspected when going about among manufacturers and dealers in the ma-

chinery and supply trade, or when visiting other industrial works where they were always glad of an opportunity to explain and exhibit the strong features of their own lines of manufacture, it thereby resulted that the purchasing agent was placed in a very favourable position to keep himself thoroughly posted in many directions such as indicated that were of interest and much value to their own concern, and he was able to impart this information to his associates when it was desired for service in the business.

For example, the drawing room or the engineering department might want to ascertain what materials in the market would be best and most suitable for certain conditions or to meet specifications that had to be conformed to in designing large engines or other important machinery so as to make up the designs in accordance with all the requirements and be certain of the ability to obtain all the materials promptly called for by the drawings and at a definite moderate price, so that the final result would be satisfactory, not only from an engineering point of view, but in a commercial sense as well.

The specific inquiry might happen at one time to be for a special kind of steel for sets of piston rods, with coupling nuts for same, for a service of unusual severity, or the material for the crankshafts, connecting-rods and other parts, or heavy steel, gun iron or bronze castings would be wanted. Sometimes, also, unusually large and heavy bed-plates or cylinders beyond the capacity of the tools at the works might be wanted. At other times, owing to the pressure of urgent work in all departments, it was desired to place orders for pattern work, iron and brass castings and machine work with responsible outside concerns having proper facilities to undertake the same and guarantee satisfactory results, and the purchasing agent, as it happened, was uniformly able to state, either from his own knowledge and experience or else having quickly ascertained by communicating with prominent manufacturers that he knew of, just what they were willing to undertake and to guarantee as regards all such materials and parts of machinery. In this way all such matters went forward, either in our own shops or in others, upon a sure and entirely satisfactory basis.

At other times information might be wanted by the engineering department as to the standard dimensions, strength or other data concerning large gate valves, check valves or other kinds of valves; about large cast-iron piping and specials or structural materials, such as heavy beams, girders and the numerous other appurtenances of an outfit, so that the data obtained might be incorporated in the drawings about to be made. Such preliminary information was sought in this way and cheerfully given, or specially obtained when not at hand by the purchasing agent, who was in close touch with the sources of information, because the important decision had at length been reached that it was much better, more satisfactory and far cheaper to give careful attention to all such matters at the outset, and also to always use standard goods, such as could be had readily in the market, in preference to any special goods whatever. The latter always cost more, and what is even worse, they occasion serious delays, as every experienced manufacturer and dealer knows.

In line with this idea, it was also sought to discourage designing or making up any special device to be used in connection with the machinery the concern produced that was already made by other concerns more distinctly in that line, and, therefore, better equipped to manufacture it to advantage. For such apparatus or appurtenances some similar or equivalent devices or articles in the market would be suggested, and thus divert that much effort in our own works to what was more profitable.

To go even a step further, as business increased, demanding more space, machinery and men, it was suggested that such standard articles of manufacture as bolts and nuts of all kinds, coiled and tempered steel springs, certain articles made of sheet brass and of copper, and the like, also movements requiring special gearing, should be almost entirely ordered of other manufacturers, who, making a specialty of such work, could do it better and cheaper than ourselves, unless we were organized for just such special work. Accordingly, after conferring with the superintendent from time to time, quite a large number of small parts, such as alluded to, were ordered of outside concerns at lower prices than those of our own make and for goods that were uniformly better, because the other people had the special equipment and expert supervision that enabled them to do it.

The great gain, however, was in having more room for the additional men and machinery that were needed as business increased, with the further advantage that, if dull times ever came, there would be less trouble to adjust things accordingly than if all lines of manufacturing had been uniformly expanded instead of contracting or entirely eliminating some of them, as the foregoing arrangement enabled them to do.

The purchasing agent alone determined where the orders were to be placed for all goods, which discretion he exercised to the best of his ability, having absolutely no friends to please in the trade, and being under no obligations whatever to favour anyone more than another. Nor did the foremen or heads of departments undertake to specify when making out their requisitions whose make or brand of goods should be used. In fact, except in very rare instances—and then only for good reasons—this rule was always adhered to by the concern itself. The strict observance of this was very important, because it secured a complete independence for the purchasing agent and obtained for us much better prices and quicker deliveries than would otherwise have been possible, and it kept everyone with whom we were dealing right up to the mark, ready and willing to do his best, because everyone realized that he was being justly treated, and that merit alone was what counted in securing orders.

# REINFORCED CONCRETE WORK IN MARITIME SITUATIONS

By Brysson Cunningham

REINFORCED CONCRETE, as a system of construction, has now long since passed out of the merely experimental stage. Introduced some fifty years ago, it met with but scanty and indifferent notice at first—an experience shared by many other estimable inventions—and it was only towards the close of the last century that it attained any degree of popularity; but, since that time, it has taken such a firm and extensive hold on the public interest as to fully compensate for the coldness of its earlier reception, and to make up any leeway due to former neglect. Numerous modifications and distinct types diverging from the original scheme have sprung up in all directions. These rival each other in the scientific basis of their construction, and differ in the precise arrangement of the reinforcement, each having its own circle of adherents, although the fundamental principle is in all cases the same. The engineer, the architect and the builder have, therefore, a wide range of choice at their disposal in regard to design.

As the various systems are numerous, so, too, the applications of reinforced concrete are manifold. It has been adapted to the loftiest "skyscraper" and to a window frame, to a telegraph pole and to a retaining wall, to a bridge and to a boat. This marvellous adaptability of the material renders it one of the most remarkable features of modern constructive science, and one wonders whether any limits at all can be assigned to the range of its utility. Interesting, however, as it is, consider the subject as a whole, and, instructive as it would be to follow it through all its varied phases, the scope of the inquiry would be far too wide for a single paper. Restrictions of space compel us to limit our observations to one particular aspect of its usefulness, and we propose to review the special features of reinforced concrete work associated with its use in dock and harbour work, and, indeed, in maritime situations generally.

Maritime structures, comprising piers and jetties, quays, wharfs and coastal embankments, are subject to conditions of a more trying and destructive character than those which fall to the lot of inland structures. Partial immersion in water, with alternations of dryness and wetness, due to the flux and reflux of the tide; complete exposure to the fiercest storms, to the onset of heavy seas, and to the drift of wind-driven spray; subjection to concussion and collision from passing vessels and the abrasion of craft moored alongside—all these varied experiences, either constantly undergone or repeated at short intervals, form an ordeal of strength and endurance which any but the most substantially built structures would fail to survive. And hence it is that, in considering the applicability of reinforced concrete to maritime situations, we must take into special account the very destructive and inimical character of its environment.

We may summarize our observations under a series of heads. In the first place, we propose to discuss the strength of the material to resist, (a) local concussion, (b) distributed pressure, and (c) abrasion. Then

NEWLYN QUAY, SHOWING MOUCHEL-HENNEBIQUE SYSTEM OF REINFORCED CONCRETE. L. G. MOUCHEL & PARTNERS, LONDON. ENGINEER, MR. W. T. DOUGLASS

we will consider its durability in regard to (a) sea-water, (b) alternations of dryness and moisture, (c) fluctuations of temperature, and (d) attacks of living organisms; and lastly, we will offer some remarks upon its economy, as compared with other materials.

Concrete, being a mineral conglomerate, is unquestionably of a brittle nature. It certainly will stand blows of some considerable force without appreciable damage; but when the breaking point is reached fracture, as in the case of stone, takes place abruptly and without much warning. In the testing machine, when compressed to destruction, it crumbles into fragments, minute particles and dust. There is relatively little resilience or elasticity in concrete, certainly none in comparison with the elasticity of steel. Consequently, when blows or very heavy pressures are brought to bear upon the thin outer covering of concrete which encloses a steel reinforcement, there is every tendency for pieces of the former material to be chipped away. This constitutes a very special defect of reinforced concrete in connection with sea-structures, since the removal of a small piece of concrete at a corner or edge will probably expose the inner steelwork to corrosion of a particularly rapid character.

Even when fracture does not actually take place, the effect of any sudden and intense stress is to produce a number of minute hair-cracks, which must inevitably become avenues for the access of moisture to the interior. Another danger is that large cracks and chippings below the water-line may escape notice, even if actually sought for; and, in any case, it is a troublesome matter to effect their repair. To avoid, therefore, the risk of consequences so

NEWLYN QUAY IN CONSTRUCTION. MOUCHEL-HENNEBIQUE FERRO-CONCRETE SYSTEM. ENGINEER, MR. W. T. DOUGLASS

CONCRETE PIERS AND CONSTRUCTION WORK ON REINFORCED CONCRETE JETTY FOR VERNON & SON'S MILLS, VICTORIA DOCKS, LONDON. CUBITT CONCRETE CONSTRUCTION CO., LONDON

grave, it becomes not only necessary to see that the steelwork is amply and efficiently covered, but also that the concrete work itself is protected by timber fendering of adequate strength to resist local shocks and distribute the pressure over a wide area. When this precaution is properly observed there is not much danger of untoward results.

The same expedient is of assistance in avoiding the ill effects of abrasion and chafing, due to vessels moored in a tideway against a wharf or quay. It is easier and cheaper to replace a wornout timber rubbing piece or waling than to effect constant repairs to a lacerated and broken concrete facing. No vessel, therefore, should be allowed to come into actual contact with reinforced concrete work; a piece of timber should always be arranged to intervene.

Yet in spite of all precautions which may be taken to obviate the risk of damage by impact, accidents will happen, and collisions do occur from time to time. A most instructive, though disastrous, incident happened not very long ago in the Thames, when the steering gear of a large steamer of 8,000 tons went wrong and she drifted across the channel into the Purfleet pier, carrying away seven or eight of the piles and some 20 superficial feet of the decking. The extent of the damage was such that the whole of the end of the pier for about 20 feet in length, with the exception of two piles, had to be reconstructed. The cracked and broken concrete was re-

PILE AND JETTY WORK IN COURSE OF CONSTRUCTION AT VERNON & SON'S MILLS, VICTORIA DOCKS, LONDON. CUBITT CONCRETE CONSTRUCTION CO., LONDON

moved and the piles withdrawn. The work of cutting away the bent and twisted steelwork was tedious and costly, as can well be imagined. This indicates another serious drawback to the use of reinforced concrete in maritime situations, which must not be overlooked in any fair review of the scope and utility of the material in question. When steel rods are contorted beyond possibility of straightening the repair or replacement of a damaged pile becomes an expensive operation, incomparable with the more economical treatment of a timber pile.

The foregoing incident was related to the Engineering Conference at Westminster last summer by Mr. Meik. Another interesting experience of the same kind was mentioned by Mr. Wentworth-Shields, as occurring to a coaling jetty at Southampton.

GENERAL VIEW OF PURFLEET PIER. HENNEBIQUE SYSTEM OF FERRO-CONCRETE. L. G. MOUCHEL & PARTNERS. ENGINEERS, W. P. & C. S. MEIK

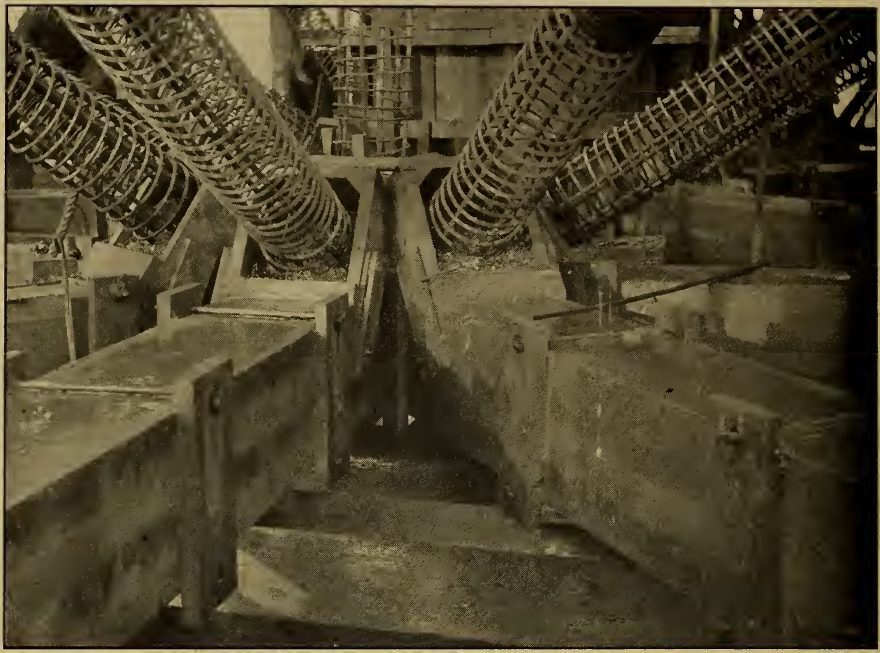
A steamer collided violently with the quay, breaking two piles and the beams they supported. On examination by divers, it was found that the piles were broken down to a level of 12 feet below low water. The broken rods were cut away by the divers, and new lengths joined on to the undamaged portions by means of steel tubes. The pile was then remoulded with concrete within a temporary casing, extending the full height of the replacement, from which the water was pumped. Mr. Wentworth-Shields added that the operation showed how easily and effectively steel-concrete could be repaired. The comment as regards efficiency is, no doubt, perfectly justifiable; but as regards the ease, with its implied inexpensiveness, is certainly open to question.

The question of brittleness is one of special importance in regard to the driving of piles. Piles are usually forced into the ground by the impulse of a heavy ram falling from a height, or by means of blows from a steel hammer. In either case the concussion with the head of the pile is very great. The heads of timber piles are frequently split and splintered under this driving action, and although the vibration of the blow may be somewhat reduced by the employment of a heavy ram with a low fall, yet in the majority of cases it is absolutely necessary to protect the head of a concrete pile by apparatus of a rather complicated nature. Thus, in one instance there is first an old sack placed upon the top of the pile and over this a steel helmet, the interior space being filled with sawdust. Not a very long time elapses after driving has commenced before the sawdust becomes solidified into a compact mass and has to be removed. Above the steel helmet, and between it and the ram, is a short wooden dolly. Even in spite of all these precautions the head of a pile sometimes gets broken and has to be made good.

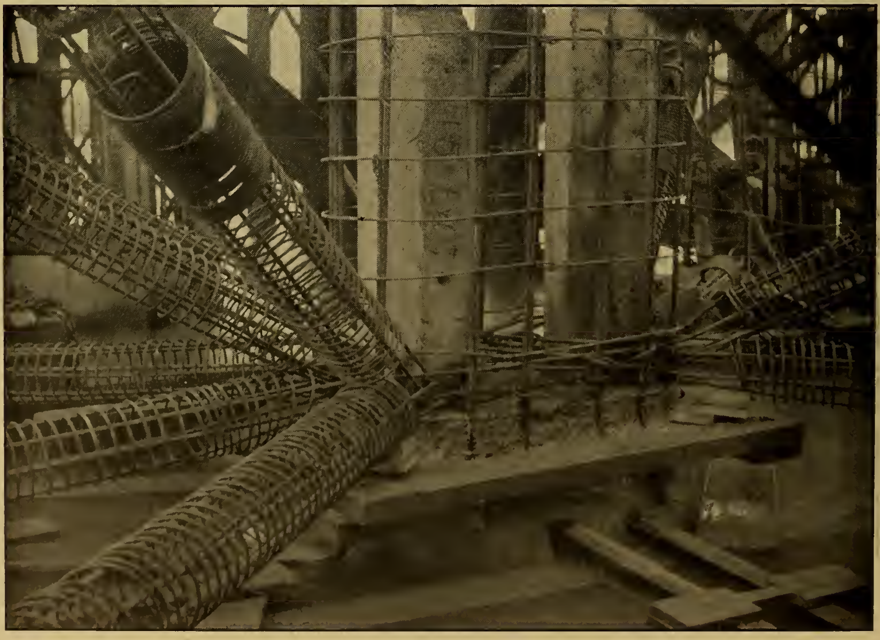
The intervention of so many different parts between the ram and the pile robs the blows of a large proportion of their useful driving effect, probably of as much as 40 or 50 per cent. And it is only right to mention that it is specially claimed for a system of spiral reinforcement (Considère system) that the resilience of the arrangement is such that the blow may be delivered directly on to the head of the pile without fear of injury. It is stated that piles 57 feet

PURFLEET PIER. HENNEBIQUE SYSTEM. L. G. MOUCHEL & PARTNERS. ENGINEERS, MESSRS. W. P. & C. S. MEIK.

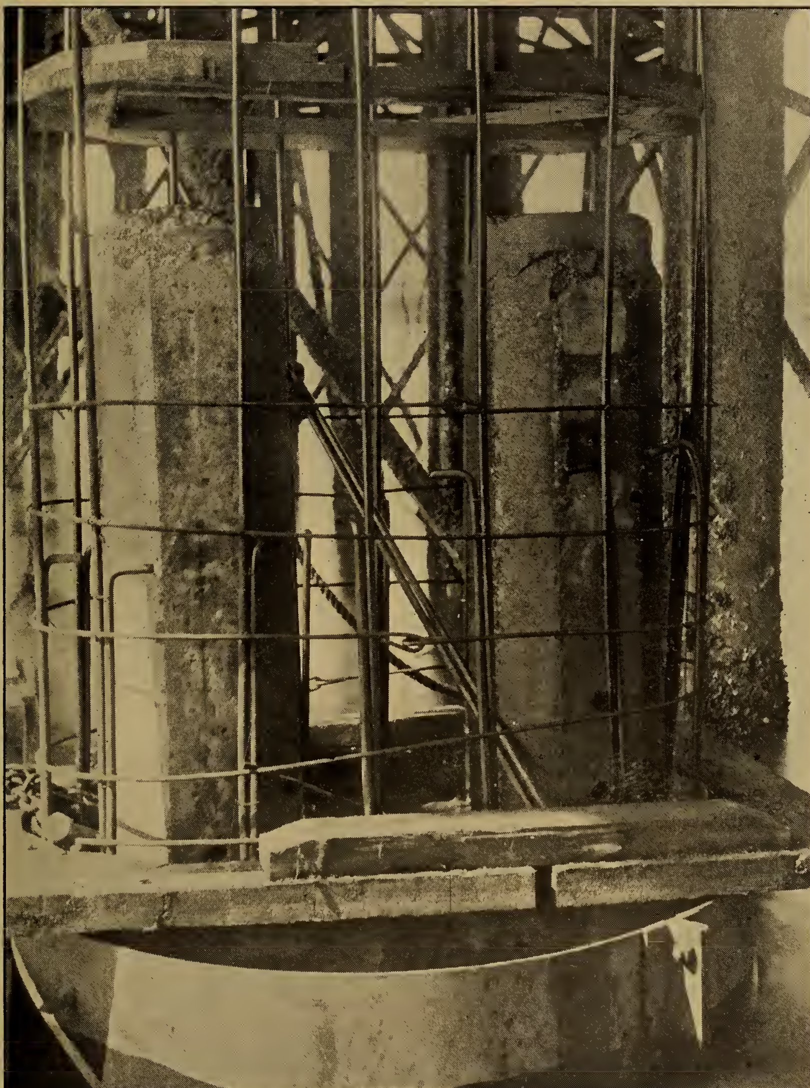
REINFORCED-CONCRETE JETTY FOR MESSRS. ARMSTRONG, WHITWORTH & CO., LTD., NEWCASTLE-ON-TYNE. MOUCHEL-HENNEBIQUE FERRO-CONCRETE.
L. G. MOUCHEL & PARTNERS, LTD., LONDON



DETAILS OF THAMES HAVEN RECONSTRUCTION, SHOWING THE HOOPED REINFORCEMENT OF THRUST MEMBERS. CONSIDERE CONSTRUCTION CO., LONDON



HOOPED REINFORCEMENT FOR STRUTS AND COLUMNS IN THE RECONSTRUCTION OF THAMES-HAVEN JETTY HEAD. CONSIDERE CONSTRUCTION CO., LTD., LONDON



DETAIL OF RECONSTRUCTION THAMES-HAVEN JETTY HEAD FOR THE LONDON & THAMES-HAVEN OIL WHARVES, LTD., BY THE CONSIDERE CONSTRUCTION CO., LTD., LONDON

long have been driven several feet into limestone rock by rams of 2 tons weight falling through a distance of 6½ feet on the unprotected heads of Considère piles.

Returning to the main question, it will be allowed that reinforcement concrete jetties and wharfs, if properly protected by wooden fendering, are not more susceptible to damage from abrasion and concussion than are timber or steelwork structures of equal strength under similar conditions. There are some enthusiastic champions of reinforced concrete who claim for that material a greater resistance to wear; but their statements are not borne out by experience, and

RECONSTRUCTION OF JETTY HEAD AT THAMES-HAVEN. CONSIDERE CONSTRUCTION CO., LTD., LONDON

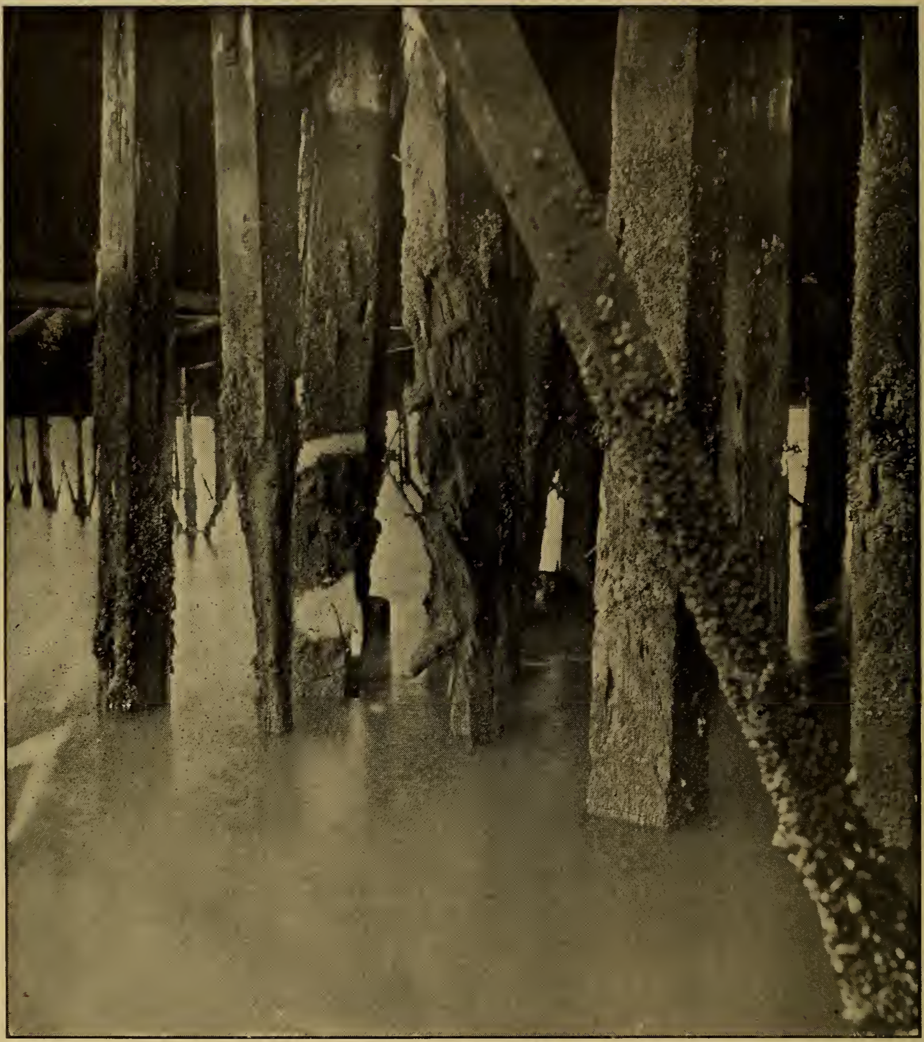
their enthusiasm rather detracts from the value of their judgment. Treated reasonably, however, and with due allowance for its lower degree of elasticity, reinforced concrete work may be made to serve with perfect satisfaction in quay and wharfs, and this is all that can be expected or desired.

Our next consideration is in regard to durability, and this point is of scarcely less importance than that of strength and efficiency. It is to be regretted that, as yet, the length of time which has elapsed since the completion of such instances of reinforced concrete work on the seaboard as are available for reference does not permit of any very certain or general conclusion being drawn as to their longevity. Very grave charges of deterioration have been made against Portland cement concrete when exposed to the chemical action of salt water, and though in regard to concrete properly made these charges have been rebutted—and, in the writer's opinion, most conclu-

UNDERPINNING WEST PIER, NEWHAVEN. SHEET PILING OF REINFORCED CONCRETE, COIGNET SYSTEM, EDWARD COIGNET, LONDON. W. HILL & CO., CONTRACTORS



CATARACT DAM, NEW SOUTH WALES GOVERNMENT, AUSTRALIA. LIDGERWOOD CABLEWAYS HANDLING CONCRETE. DOWN-STREAM FACE, SHOWING VALVE HOUSE OF REINFORCED CONCRETE



A GROUP OF WORN TIMBER PILES SUSTAINING THE ROYAL PIER AT SOUTHAMPTON BEFORE BEING REPAIRED

sively rebutted—yet the evidence adduced unmistakably shows that great care is necessary in the selection of ingredients, in the adoption of proper precautions, and in the character of the mixing. Inferior and imperfectly manufactured concrete will undoubtedly disintegrate, and this fact must attentively be borne in mind. There are incontestable instances where failure of concrete work has taken place, and the causes have been traced to neglect of these fundamental precautions. Some authorities have gone so far as to take up the attitude of stating that the decomposition of cement by sea-water is inevitable, but a consideration of a large number of cases of maritime works exposed to the action of the sea for many years does not justify such extreme pessimism. With good material and proper workmanship there is indeed no reason to apprehend evil consequences. Care must certainly be exercised, but this is essential to all sound constructional operations.

THE SAME PILES SHOWN ON OPPOSITE PAGE REPAIRED BY BEING ENCLOSED IN REINFORCED-CONCRETE SLABS, WITH GROUT FILLING. SYSTEM OF MR. E. COOPER POOLE, ENGINEER OF HARBOUR BOARD, SOUTHAMPTON.

Steel is, of course, subject to corrosion when exposed to a moist atmosphere, and still more so in saline or acidulous environment. This being the case, further evidence must be forthcoming, and, indeed, will be anxiously awaited, before any very definite pronouncement can be made as to its behaviour in reinforced concrete. So far, the results have been satisfactory, although they only cover a very recent period. There is, fortunately, however, no reason to anticipate adverse experience in the future. Up to the present the evidence demonstrates that the concrete coating acts in a decidedly beneficial manner upon embedded steelwork. Rods which have been cased in concrete and examined after an interval of many months, and, in some cases, of several years, exhibit a complete absence of rust, and rusty rods similarly treated have become quite

QUAY AT DUNDEE, SHOWING MOUCHEL-HENNEBIQUE FERRO-CONCRETE SYSTEM. L. G. MOUCHEL & PARTNERS
ENGINEER, MR. J. HANNAY THOMPSON

clean. The surface of the metal acquires a peculiar glaucous bluish tint, indicating the formation of a skin or film, which, strange to say, on exposure to the weather, does not readily rust, like a bar of the untreated metal. Mr. W. T. Douglass has recorded that, when taking down the old (Smeaton's) Eddystone lighthouse in 1881, he found a small bundle of iron rods embedded in Aberthan lime, which had evidently been left accidentally in the masonry. The condition of these rods when taken out was just as they had come from the mill, and there was no mark of rust upon them. Considering that Smeaton's lighthouse dates back to 1757, the evidence afforded by the incident is significant and valuable.

For durability and the efficient protection of the steel core from deleterious influences, it is essential that the concrete be impermeable, and this condition can only be obtained by the adoption of proper proportions for the ingredients and proper manipulation. If the aggregate be composed of gravel of moderate size, combined with not less than two-thirds of its bulk of sand, with one part of cement to every two parts of sand, and if the whole be thoroughly incorporated by turning over several times, both dry and wet, there will not be much occasion to fear untoward results. As an additional precaution, the work should receive a coat of pure cement wash after the moulds have been stripped.

So far as has been observed, alternations of dryness and wetness and fluctuations of temperature in this country do not appear to affect reinforced concrete structures adversely, if at all. Possibly they may exercise greater influence in other climates, but the writer has no data bearing on the point.

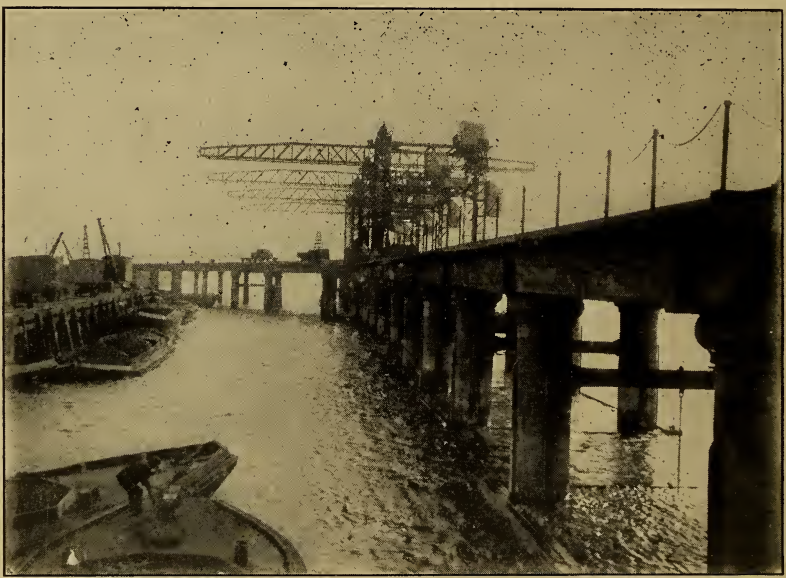
One very striking feature in connection with the use of reinforced concrete for piles in place of timber is its apparent immunity from attack by seaworms. All kinds of wood are subject to the depredations of these pests, though some varieties,



REBUILDING GOVERNMENT BREAKWATER AT CLEVELAND, OHIO. SHOWING THE USE OF LIDGERWOOD CABLEWAY FOR HANDLING CONCRETE FILLING.

such as greenheart and jarrah, seem to be less ravaged than others. Pine and pitchpine are freely attacked, and creosoting them affords no protection. Seaworms are not known to attack concrete. And this is somewhat strange, in view of the fact that while the *Teredo* and its allies readily bore into wood and ignore stone, yet the *Pholas dactylus* and the *Saxicava* are undoubted enemies to limestone, and the chemical compositions of limestone and cement concrete are not greatly dissimilar. Yet hitherto no depredations of the last-named borers have been recorded in any concrete work, and it is to be hoped that none will be discovered.

The benefit of having a material for piles which is proof against the insidious raids of seaworms can hardly be overrated, so numerous are the instances of havoc and destruction wrought by their agency in all parts of the world, and even if reinforced concrete had no other quality to recommend it, this characteristic alone would go very far in favour of its adoption in maritime situations.



COALING JETTY AT DAGENHAM-ON-THAMES. HENNEBIQUE SYSTEM. L. G. MOUCHEL & PARTNERS, LTD., LONDON

Among other uses to which reinforced concrete has been put by harbour engineers are those of dykes, sea embankments and groynes. It has also been adapted to the construction of caissons for breakwaters: large, open boxes, which are floated out into position, sunk, and filled with mass concrete, so as to become solid blocks of immense size, over which storm waves can have little power. The buoyancy of the caisson renders it feasible to construct in this way blocks of infinitely larger size than could be handled by any available lifting appliance.

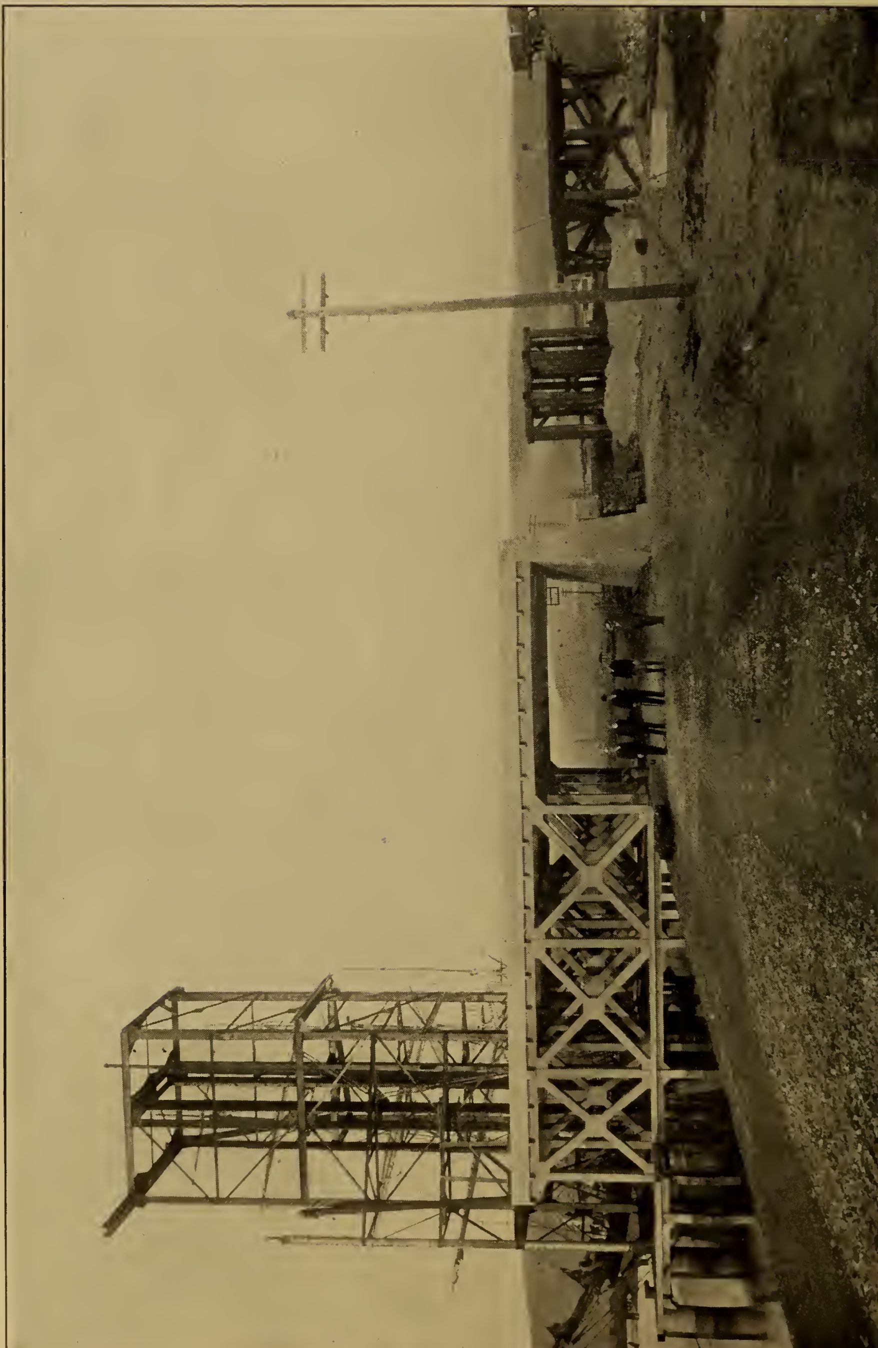
Lastly, a word in regard to cost.

At a wharf at Liverpool, with the construction of which the writer was associated, the cost of the piles (ferro-concrete, Hennébique system) was 5*s* 6*d* per cubic foot, of the framing 4*s* 6*d* per cubic foot, and of the decking 21*s* 6*d* per square yard. The piles were 35 feet long.

At Purfleet pier, on the Thames, built on the same system, Mr. Meik gives the cost at 5*s* 6*d* for the piles, 5*s* per cubic foot for the bracing, and 20*s* per square yard for the deck-



CONCRETE DRY-DOCK CONSTRUCTION AT LEAGUE ISLAND PHILADELPHIA. LIDGERWOOD CABLEWAYS PLACING CONCRETE FLOOR ON PILING



PORT TALBOT COAL TIP. MOUCHEL-HENNEBIQUE FERRO-CONCRETE SYSTEM. ENGINEER, MR. W. CLEAVER. PORT TALBOT DOCKS & RAILWAY CO.

RECONSTRUCTION OF TOWN QUAY, SOUTHAMPTON, IN REINFORCED CONCRETE BY MESSRS. D. G. SOMERVILLE & CO., LONDON.
ENGINEER, MR. E. COOPER POOLE, A.M.I.C.E.

ing. The piles were of considerable length—as much as 70 feet in some instances.

At a wharf at Dundee, Mr. Thompson states the cost of the piles, which were from 40 to 45 feet long, to have been from 4*s* 4*d* to 5*s* 2*d* per cubic foot. The bracing cost 5*s* 10*d* per cubic foot.

At a quay staging alongside the Gambetta quay at Boulogne the cost of the piling, as given by M. Voisin, works out to 5*s* 10*d* per cubic foot, the bracing to 4*s* 5*d* per cubic foot, and the docking to 19*s* 5*d* per square yard.

These four instances from localities widely apart show a uniformity of unit cost which is very remarkable. The total costs per square yard of quay surface are, of course, more widely divergent, since there is a great difference in the length of the piles and in the height, closeness and extent of the framing. But these are merely matters of design. Assuming the unit costs to be fairly typical, we see that the prices per cubic foot of reinforced concrete work compare exceedingly favourably with timber work. Greenheart piles would cost at least more, and pitchpine piles very little, if anything, less, while the latter would be so inferior in strength that a very much greater quantity of piling would have to be provided—nearly as much again as in the case of reinforced concrete work.

Altogether, a review of the new system of construction, as applied to maritime work, leads to a very favourable verdict, and while there are certain precautions to be observed, these do not entail any undue difficulty, and the prospect before reinforced concrete, in this as in other directions, is that of a field of widely extending usefulness.

There is an interesting application of concrete to piles in which the concrete, instead of steel, plays the part of reinforcement. In this case the piles are of timber, damaged, worn and worm-eaten for a portion of their length between, say, the ground level and high-water level. In order to repair damage of this kind without having recourse to absolute removal of the pile, Mr. Cooper Poole, the harbour engineer of Southampton, hit upon the expedient of encasing the damaged portion of the pile in concrete slabs, the space thus enclosed being subsequently grouted in with cement. The method answered admirably, and it has been extended so that piles may now be formed with a wooden toe, or end driven through a concrete cylinder, by means of a dolly, which is withdrawn on completion of the operation, and the pile is then consolidated up to the required height. The woodwork is thus perfectly protected from exposure, and it serves at the same time as a foundation for the pile.

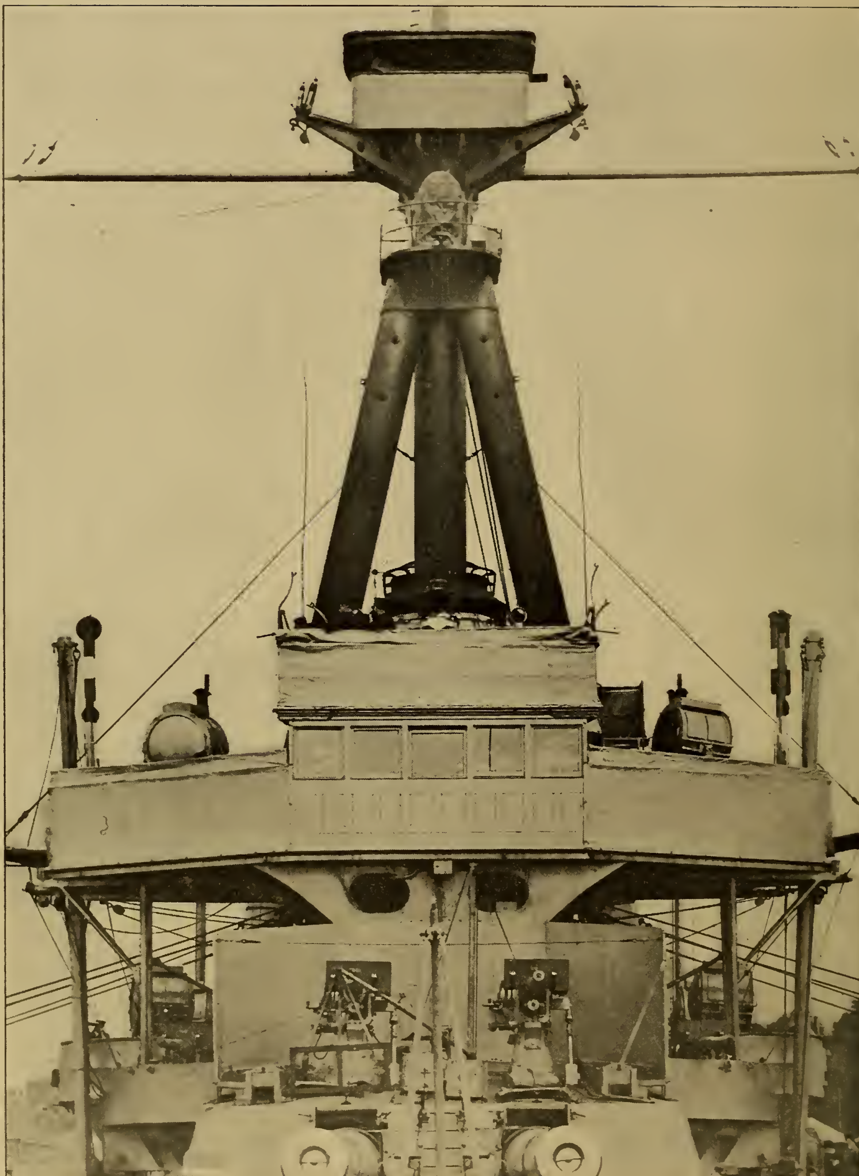
# THE RACE FOR NAVAL POWER

By Archibald S. Hurd

WHATEVER may be the immediate future of shipbuilding generally, those firms throughout the world who make a specialty of warship construction—guns, armour, armament, engines, boilers, etc. — have before them a period of unparalleled activity. The prospective requirements of the leading Naval Powers are more extensive than ever before, not forgetting the period of almost feverish shipbuilding for Russia which preceded the outbreak of war with Japan, when the yards of Germany, France and the United States were laid under contribution.

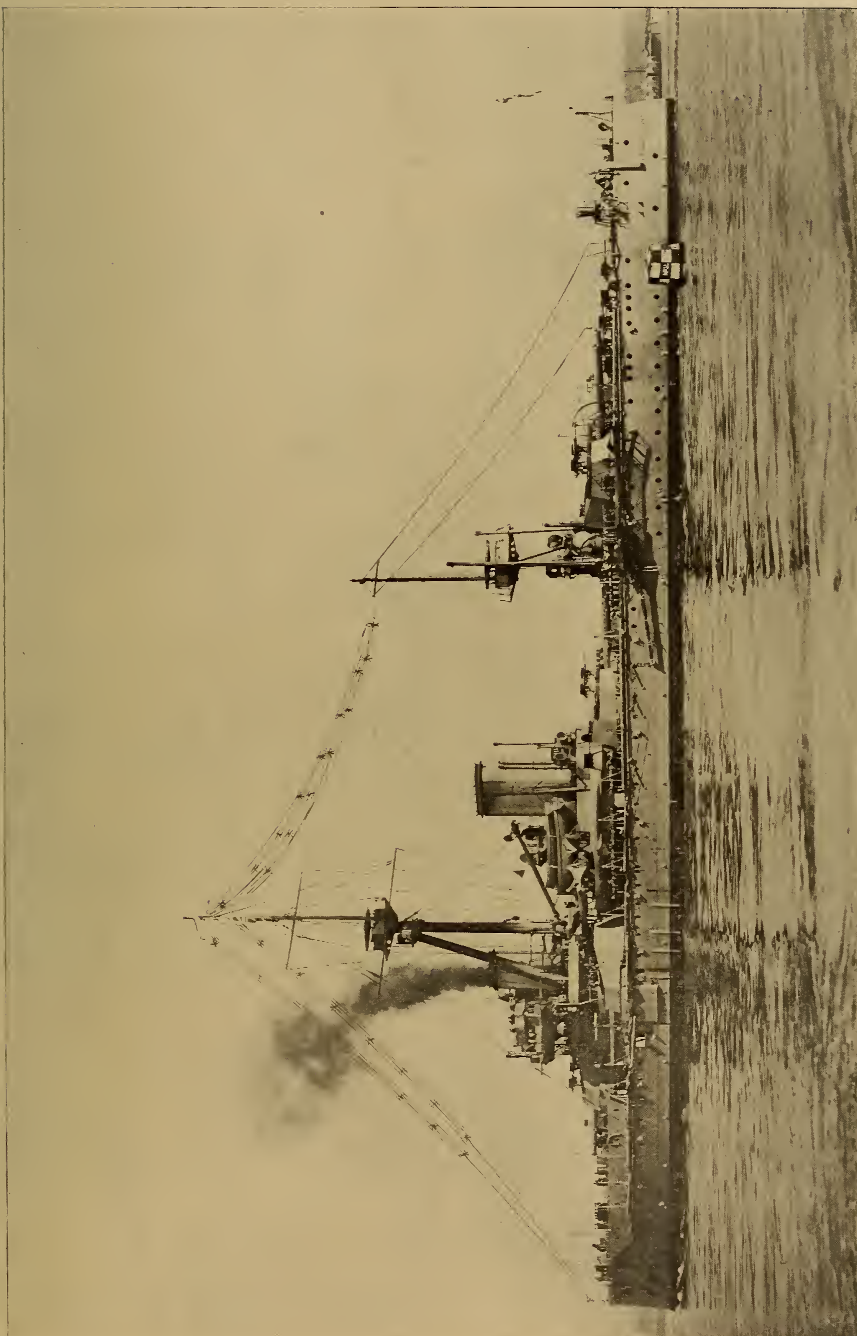
What is the cause of this renewed competition? The question is not one to which a simple answer can be given. It is a matter of international policy, and all that is possible is to supply a summary of events which, though political in character, is essential to a full appreciation of the trend of the naval policy of the great powers, and is made without any bias—a mere statement of fact. The phenomenal activity now inevitably resembles that which was observed after the first gathering at The Hague, but is much more pronounced. Nine years ago, when the first Peace Conference at The Hague was called together, there was reason to think that the naval movement, which had affected all the principal countries of the world, had spent itself; but immediately the delegates returned to their capitals it was resumed with zest. It is a proverb that a diplomatist's language is used to conceal his thoughts, and when the delegates of the powers met at The Hague in 1899 the very studied facility with which they skated over delicate subjects served to excite suspicions and engender a feeling of unrest, tending to a higher standard of expenditure upon defense. Between the close of the first Peace Conference and the meeting of the second this sense of uneasiness found expression in an increase in British naval expenditure of seven and a half million sterling annually. On the other hand, the outlay on the French, German, Russian, Italian and United States fleets was augmented by nearly twenty-four and a half millions sterling. In these years France and Italy devoted to their fleets about half a million each more than before, the expenditure of Russia rose by upwards of four millions, that of Germany by nearly five, while the appropriations for the American fleet were increased by fourteen and a half millions sterling.

This, in briefest summary, is the story of the rising cost of naval armaments in the years immediately succeeding the first Peace Conference at The Hague. Another gathering of the delegates at The Hague has, strangely enough, been followed by indications of a world-wide movement towards a yet higher standard of naval expenditure. It is unnecessary to endeavour to trace the mental



THE TRIPOD MASTS OF THE DREADNOUGHT

processes which have been going on in the minds of the rulers of the world to account for the apparent contradiction between the beneficent opinions which were expressed at the Peace Conference and the subsequent executive acts. In its broader aspects this gathering proved a failure. It was found impossible to discuss proposals for a proportionate reduction in naval armaments, and, apart from the expression of pacific views, which appear to have carried little weight, the delegates had to content themselves with an elaborate discussion of the rules which should govern war. Thus what was originally intended to be a peace conference became, as a



THE BRITISH BATTLESHIP DREADNOUGHT

matter of fact, a war conference. The discussions on war, whatever their results, appear to have rendered the great powers dissatisfied with the scale of naval defense hitherto adopted. Consequently, we are again faced with renewed rivalry, which will keep the great warship-building yards of the world in a state of unprecedented activity, and, in some cases, test the national resources almost to the breaking point.

The serious character of the new situation cannot be better illustrated than by the position into which the British Government have been forced. The Liberal Ministry came into power definitely pledged to a reduction of armaments. On the strength of the large sums which were to be saved out of the votes for the defensive services politicians supporting the government had promised their constituents a series of social reforms. In spite, however, of these promises, and in spite of the exceedingly modest programme of new construction which is provided for in the new naval estimates, and a reduction in the number of men in the Army, the expenditure this year on defense shows a total increase of £600,000. The increase would have been very much greater but for the fact that at the moment the relative position of the British Navy is assured, and the government determined to postpone making any response to the programmes introduced by other powers. Only the bare necessities of the traditional Two-Power Standard are provided. Thus only one battleship and one large armoured cruiser are to be laid down in the largest classes of men-of-war, in addition to six small protected cruisers, sixteen destroyers and about eight submarines. It is the smallest armoured programme for

JAPANESE BATTLESHIP KATORI AT FULL SPEED

LAUNCH OF THE JAPANESE BATTLESHIP KATORI AT THE YARDS OF MESSRS. VICKERS, SONS & MAXIM, BARROW-IN-FURNESS

H. M. S. NATAL AT FULL SPEED. BUILT BY VICKERS, SONS & MAXIM, BARROW-IN-FURNESS

over ten years, and it is admitted that it is the lull, so to speak, before the storm—a rest before a further advance. Next year five or six more Dreadnought ships must be laid down, and hence onwards the output of war material will be on a scale without any parallel in the history of the British fleet. Great Britain is at present merely waiting and watching events abroad.

On the other hand, in Germany a new naval act has been passed, making provision for expenditure on the fleet during the next eleven years of nearly one hundred and ninety millions sterling, apart from the outlay on the enlargement and deepening of the Kiel Canal, which is to be made under other votes. The vital change introduced into the new German naval act has to do with the age at which armoured ships shall be considered obsolete. In the act of 1900 this period was fixed at twenty-five years, and the necessary readjustment of the programme to a twenty-years-age standard brings into the ensuing eight years four more battleships for replacement. The old battleships which are to be replaced are vessels of about 4,000 tons, and their places will be taken by Dreadnoughts of from 18,000 to 20,000 tons, so that the reference to "replacement" is merely a form of words, since for many years past these little ships of insignificant power have not been regarded as forming part of the active fleet, whereas the ships which in future will bear their names will be battleships of the maximum size, speed and power.

This point may, perhaps, be best indicated by setting out in "deadly parallel" the general details of the *Ersatz* vessels building and to be laid down this and next year and the old ships they are nominally replacing, as is done below:

OLD SHIPS.

| Name. | Ships. | Displacement (Tons). | Main Guns. |
|---|---|---|---|
| Baden...... | 4 | 7,400 | 6—10.2 in. (17 calibres) |
| Oldenburg.. | 1 | 5,200 | 8— 9.4 in. (30 calibres) |
| Siegfried.... | 5 | 4,100 | 3— 9.4 in. (30 calibres) |
| Total.... | 10 | Avg. 5,530 | |

REPLACEMENT.

| Name. | Ships. | Displacement (Tons). | Main Guns. |
|---|---|---|---|
| Baden...... | 4 | 17,900 | 12—11 in. (50 calibres) |
| Oldenburg.. | 1 | 17,900 | 12—11 in. (50 calibres) |
| Siegfried.... | 5 | 17,900 | 12—11 in. (50 calibres) |
| Total.... | 10 | Avg. 17,900 | |

In addition, one armoured cruiser (Blucher) of just under 15,000 tons has just been launched; another, *F*, of 18,000 or 19,000 tons is building,

and two more will be on the stocks by the summer of 1909.

It will be seen, therefore, that the reference to "replacement" is a mere form of speech. The fact is that old and small coast-defense ships of poor armament, and slow speed, and very limited radius of action, which have long since ceased to be of war value, are passing on their names to veritable battleships of the very largest size, the heaviest all-big-gun armament, high speed and wide radius of action. At the same time, the German fleet is being strengthened by a large number of small, swift cruisers, torpedo-boat destroyers and submarines, apart from auxiliary vessels.

The new German proposals have reacted on other powers. In 1906 France adopted a shipbuilding programme under which six battleships of 18,000 tons were to be constructed. During 1907 all these vessels were either actually laid down or placed on order. Concurrently with the return of the French delegates from The Hague and the early reports of the naval intentions of Germany, the French Government deputed a committee of higher naval officers to reconsider the necessities of the fleet. These officers have since presented a report to the government strongly recommending that six more battleships of the largest size, besides other vessels, should be constructed as soon as facilities are available. Arrangements are now under consideration for laying down these six ships on the slips which will be vacant when the vessels of the 1906 programmes are launched.

In Italy, where the naval necessities have to be met as best may be on very limited financial resources, the naval Budget for the present year includes provision for the building of a battleship of 16,000 tons. This is the largest and most powerful ship which has yet been designed in Italy, and it is merely the precursor of a far larger programme. Arrange-

H. M. S. SENTINEL. BUILT BY VICKERS, SONS & MAXIM, LTD.

THE GERMAN BATTLESHIP PREUSSEN

ments are already under consideration for raising the necessary funds to enable four more battleships of 19,000 tons to be constructed, at a cost of about eight millions sterling. If it is decided to lay down all these ships in Italy, the progress which will be made with them will be comparatively small, because the resources of Italy are not adequate for the building of four such large vessels simultaneously in a short period in addition to smaller ships.

Italy's closest neighbour, Austria, is naturally not content to sacrifice her position as a naval power, although her fleet has always been of secondary importance to her army. A new programme of construction for the Austrian Navy has been prepared, and makes provision for the commencement of three battleships of 14,500 tons, three armoured cruisers of 9,500 tons, a protected cruiser and twenty torpedo-boats. Small though these battleships are in displacement, their armament will be only slightly less powerful than that of the *Lord Nelson,* of the British Navy. It is intended that each of the battleships shall carry four 12-inch and eight 9.4-inch guns, besides a powerful anti-torpedo armament. In the case of the Austrian battleships, as with those of Italy, a considerable economy of weight is possible, owing to the fact that it is not considered necessary to give these ships a large radius of action, in view of the fact that they would never act far away from a fixed base.

The last of the European naval powers is Russia. Since the conclusion of the war* with Japan many proposals have been put forward for rehabilitating the fleet; but at present no definite decision has been reached, in view of the unrest and financial difficulties which have handicapped the authorities in their anti-war policy. The four battleships which were laid down prior to the outbreak of hostilities with Japan, two in the Baltic and two in the

* In the war with Japan, Russia lost 56 men-of-war with a gross displacement of 249,000 tons, besides auxiliary vessels displacing 21,000 tons.

GERMAN BATTLESHIP ELSASS. BUILT AT THE SCHICHAU WORKS, ELBING

THE WORLD'S LARGEST BATTLESHIPS AFLOAT. DREADNOUGHT IN THE FOREGROUND GOING INTO DOCK; BELLEROPHON UNDER CONSTRUCTION

THE ITALIAN WARSHIP CARLO ALBERTO

GERMAN BATTLESHIP KAISER BARBAROSSA. BUILT AT THE SCHICHAU WORKS, ELBING

Black Sea, are still incomplete, although three were launched in 1906 and the fourth last year. A large armoured cruiser, the *Rurik,* has been built and completed at Barrow, while three smaller ships—the *Admiral Makaroff,* the *Pallada* and *Bayan*—have been launched, one at La Seyne and two at St. Petersburg. The armoured cruiser *Rurik,* it may be added, is a vessel of 15,170 tons and a speed of 21 knots; she is well armoured and mounts four 10-inch and eight 8-inch guns, in addition to twenty 4.7-inch quick-firers and eighteen smaller pieces for repelling attacks by torpedo craft. The three small cruisers are of 7,900 tons displacement and the same speed, but are less heavily armed, and some economy of weight has been effected in the armament and coal endurance. Each of these smaller ships mounts two 8-inch, eight 6-inch and twenty 3-inch guns, besides seven smaller weapons. These ships will prove no inconsiderable additions to the small fleet, and plans have already been prepared for two battleships of 19,000 tons on the all-big-gun principle. Each of these ships will carry ten 12-inch guns and have a speed of 21 knots with turbine machinery.

This rapid survey exhausts the leading European naval powers, though Spain is about to devote considerable sums to new shipbuilding. In view of the activity which is being exhibited in adding to the strength of European fleets, the naval authorities in the United States and Japan are naturally not resting upon their laurels. In his recent report to Congress Secretary Metcalf remarked:

"In foreign shipbuilding programmes of the current year the characteristic features of all are the presence of battleships of heavy displacement, destroyers and submarines, and, with the German excepted, the omission of armoured cruisers. The speed and displacement of battleships are increasing in all countries, and there is a marked tendency towards a reduction in the number of calibres of guns composing the armament. The armament of the latest type of battleships is composed

UNITED STATES BATTLESHIP "LOUISIANA"

of heavy turret guns and of smaller guns intended for defense against torpedo craft. The latter, moreover, are increasing in calibre to such a degree that, in some ships of recent design, they are of the same calibres that were used but a few years ago for the intermediate battery. The absence of armoured cruisers from the new programmes is worthy of note, and may be ascribed to the tendency towards the merging of the battleship and armoured cruiser types."

In view of these circumstances, the Navy Department recommends that Congress should authorize considerable additions to the American fleet. It was proposed that there should be laid down in the coming financial year four battleships of 20,000 tons, four scout cruisers, ten destroyers and four submarines, besides certain auxiliaries. This recommendation was strongly supported by President Roosevelt, who urged that the whole standard in naval power of men and ships should be greatly increased. The Naval Committee of Congress has since cut out two of the battleships and duplicated the provision for submarines, and in this emasculated form the programme has been submitted to Congress. If only two battleships are laid down annually the United States will very shortly cease to occupy its present position as the second naval power of the world. The action of the Naval Committee in reducing the programme has naturally occasioned considerable outburst of popular feeling, owing to the fact that, if the United States has to detach a large naval force for the Pacific, the Atlantic coast will only have a small squadron for its protection, and until the Panama Canal is completed the naval defenses of the Pacific and Atlantic slopes must be regarded as entirely separate and distinct. Even in time of war it would not be possible to bring ships round from the Atlantic to the Pacific or the Pacific to the Atlantic in less than about four months, and by that time it is probable that the die would have been irretrievably cast either for victory or defeat.

At present Japan is busily engaged in digesting her costly victories, which have thrown on the population a very much higher standard of taxation and greatly increased the national debt. In face of financial embarrassment, the requirements of the fleet have this year been kept down to the narrowest limits which are considered adequate in view of the activity of other countries. On the other hand, Japan has gained considerably in naval power by the reconstruction of valuable prizes which were taken during hostilities with Russia; a number of these vessels have been remodelled and have now joined the fleet. In spite of this gain in naval power, progress is being made in the construction of entirely new ships. The battleship *Satsuma,* of 19,350 tons, has been completed at Yokosuka, and the rather larger battleship *Aki* has been launched at Kure. Simultaneously considerable headway has been made in the construction of a group of four armoured cruisers. The *Tsukuba,* of 13,750 tons, was completed last year, and the sister ship *Ikoma* will be finished in a few months' time. Two large armoured cruisers are being completed at Kure and Yokosuka, so that in the course of the next twelve months the Japanese fleet will be strengthened in anti-war vessels of large size by two *Dreadnought* battleships and four exceedingly powerful armoured cruisers, apart from the two battleships, *Katori* and *Kashima,* which were completed in England after the conclusion of peace. The newest battleships, the *Satsuma* and *Aki,* resemble the Lord Nelson type of the British Navy in that they carry four 12 and twelve 10-inch guns, but in place of the anti-torpedo armament of 3-inch guns they are provided with twelve 4.7-inch quick firers. It has now been decided to build three

GERMAN BATTLESHIP LOTHRINGEN. BUILT BY SCHICHAU, ELBING

more battleships of from 21,000 to 22,000 tons. These are the largest and most powerful men-of-wars which have hitherto been designed in any country. It is intended to give them a speed of 21 knots, and very complete armour protection. Whereas the British *Dreadnought* carries ten 12-inch guns and no secondary armament, it is reported that these new Japanese battleships will each mount twelve 12-inch weapons and ten 8-inch pieces, and will have an anti-torpedo armament consisting of a dozen 4.7-inch guns. This is probably an exaggeration, but the armament will certainly be most powerful.

This brief survey of the naval activity of the world shows how completely all the hopes of disarmament which were entertained prior to the Peace Conference at the Hague have been falsified. The smallest naval programmes yet announced are those of Great Britain and the United States, and the largest that of Germany. The German proposals for the present year are based upon a continuous naval expansion law running from the present year to 1917, while the British and American governments still continue to frame their programme from year to year so as to make it an accurate representation of the necessities of the country—in the former case in accordance with the Two Power standard. Bearing in mind this difference in the naval methods of the several countries the programmes of construction for the coming year compare thus:

| | Germany. | Great Britain. | United States |
|---|---|---|---|
| Battleships....... | 3 | 1 | 2 |
| Armoured cruisers | 1 | 1 | 0 |
| Fast cruisers..... | 2 | 6 | 4 |
| Destroyers....... | 12 | 16 | 10 |
| Submarines...... | 6(?) | 8 | 8 |

The facts show that in face of the unparalleled ship-building activity which is promised in almost all the shipyards of the world, Great Britain and the United States, in proportion to their responsibilities, are showing the least inclination to plunge heavily into the renewed rivalry of naval armaments, evidences of which have already become apparent in other countries.

The new German programme will, however, inevitably react on all the naval powers of the world; the small, such as Holland, Norway, Sweden, as well as the great. It has been suggested, with some authority, that the British Admiralty will adopt a policy summed up in the formula—two to one against Germany; that is, for every keel laid down in German shipyards, two will be laid down in Great Britain. If this formula is adopted by Parliament, next year the British proposals for new construction must include four *Dreadnought* battleships, one Invincible (*Dreadnought* battleship cruiser), several protected cruisers and a number of torpedo craft, and in subsequent years will be as follows:

| | Battleships. | Large Armoured Cruisers. | Small Cruisers. | Destroyers. |
|---|---|---|---|---|
| 1909........ | 6 | 2 | 4 | 24 |
| 1910........ | 6 | 2 | 4 | 24 |
| 1911........ | 6 | 2 | 4 | 24 |

It is not necessary to attempt to forecast what may be necessary in the case of the British fleet after 1911, because it is said that proposals have been prepared for a new German Naval Act in that year. It may be added, however, that in the next four years, if the American fleet is to maintain its position *pari passu*, in comparison with that of Germany, three battleships, one large armoured cruiser, two small cruisers and twelve destroyers must be put in hand annually, a total of sixteen large armoured ships, eight small cruisers and forty-eight destroyers, apart from submarines.

No doubt British and American ship builders will eventually profit considerably by the higher standard of naval expenditure which is being adopted by other Powers, and it is possible that, as in the case of the Russian and Japanese programmes, prior to the war in the Far East, some foreign work will be secured. Already British firms have secured contracts for three large bat-

FRENCH CRUISER MONTCALM

tleships for Brazil and are building submarines for Austria and Japan, and it is rumoured that one of the Japanese battleships will be built in this country, and that the machinery required by Russia will also be obtained from British firms.

Whatever may be the opinion of taxpayers in the various countries who will have to find the funds, there is no doubt that British, American and continental shipbuilders may now look forward to a period of great activity, and this will become all the more marked next year, when there is every reason to anticipate that Great Britain and the United States will embark upon very much larger shipbuilding programmes. In both countries exceptional efforts will be necessary unless the existing balance of naval power in the world is to be seriously readjusted to their disadvantage. The index figure for the future will be the new German navy act. Unless the United States is to sink back into the position of third naval power of the world, it must lay down rather more ships than Germany is doing, and if the United Kingdom is to hold her own, for every German keel two must be laid down in Great Britain. Consequently we are now on the eve of a contest in warship building on an unprecedented scale.

# SOME ASPECTS OF THE POWER PROBLEM FOR THE TEXTILE INDUSTRIES

By Charles J. Kavanagh

THE subject of motive power for the textile industries has, of late, occupied a good deal of attention, and it is the writer's object to review, without prejudice, the present situation and probable developments.

Power generation and power transmission for textile factories are undergoing a metamorphosis, and whatever particular specie of generator will finally be evolved it is difficult to say. Speaking generally, till a recent date the steam engineer was predominant: the driving of textile mills his monopoly. This is scarcely the case now, for some very energetic competitors have entered the lists; the issues are keen, and will be keenly fought. If steam triumph, with which will rest the laurels, the slow-speed or quick-revolution engine, or the steam turbine? If not, will the gas engineer with his producer plant be victor over the advocate of the oil engine? Will electric transmission and driving supplant that by rope and belt? And what are the answers to all these questions? The sanguine steam engineer will give his, the gas-engine zealot his, and the electrician his. But now that we have all these sources of power generation in the field, the efficiency of one or the inefficiency of the other will be made manifest by the trend of the times; the progress of those that are found wanting will be retarded, and each will ultimately work out its own salvation.

It cannot be due to any lack of appreciation of the electric motor on the part of the mill-owner that its more universal adoption has not come about, since he has seen it thrive under the most moderate as well as the most trying circumstances. Being a shrewd man, he has had a preference rather for trodden paths than for unbeaten ways, and it is this preference, or his inertia, that the electrical engineer has had to overcome, and he is most able to tell you of its amount.

It is easy to understand the position of the mill-owner. Reliability to him was the most important factor, and so long as he secured this, together with a degree of economy as high as that of his neighbours with whom he had to compete, he was satisfied. When approached on the subject, he wished to leave the electrical equipment to his more enterprising fellows and profit by their experience. An installation to him, although it was in vogue elsewhere, savoured of an experiment, and he was within his rights in drawing a distinction between experiment and finance. What he wanted was reliable figures as to the benefit that would accrue, and these the electricians had not to give him, for they had just entered the field and were gaining experience, whilst the steam engineer had had a century of it and knew all the requirements. There is little doubt the electrical engineer got in the thin end of the wedge during the recent unprecedented activity in making extensions to existing plant, and the satisfactory results recorded here secured a wider sphere for his services elsewhere.

### THE ELECTRIC DRIVE

The requirements of the textile industry are characteristic. The materials worked with are neither coarse

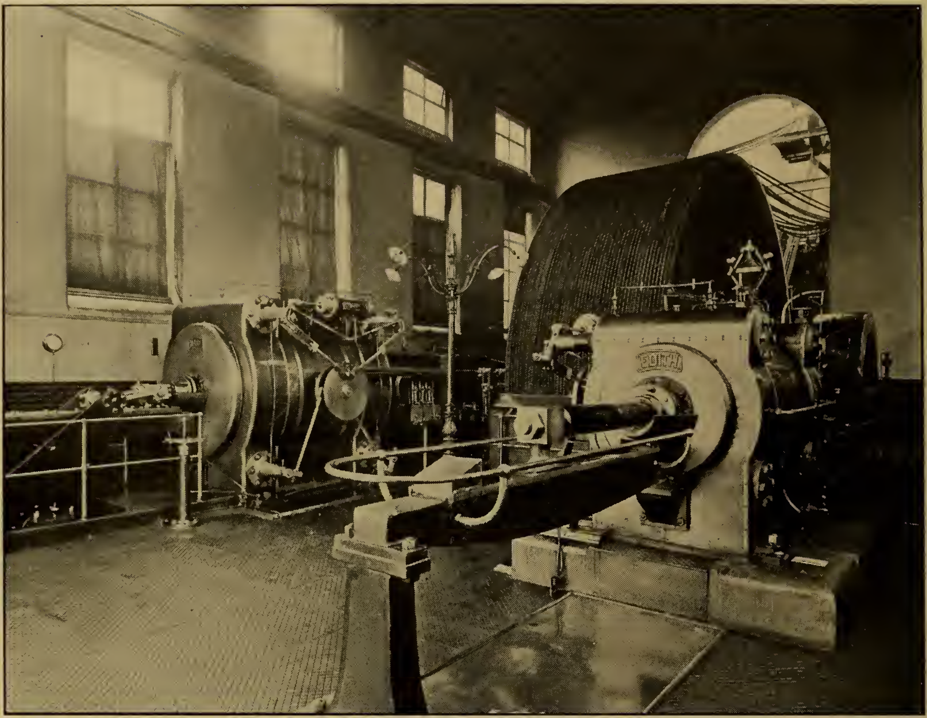


FIG. 1.—CROSS COMPOUND ENGINE OF 1400 HORSE POWER, BY MESSRS. HICK, HARGREAVES & CO., BOLTON, DRIVING A LANCASHIRE COTTON MILL. COAL CONSUMPTION FOR ALL PURPOSES $1\frac{3}{4}$ POUNDS PER I.H.P. HOUR

nor heavy, but extremely fragile, and consequently the machines required to work them must be sensitive and as free from cyclic variation as possible. And what is more adapted to these requirements than the electric motor? In the cotton industries the evenness of turning is of first importance, and this *sine qua non* is much more emphasized in the jute and flax industries, where the materials worked with have not the elasticity of cotton.

It is maintained that an electrical equipment is justified if only for the steadier drive and greater flexibility which result from its adoption, even if the cost per unit is within a reasonable margin in excess of the cost per unit by a purely mechanical drive. The interest on capital charges, it might be remarked, in electrical equipments form a prominent factor, and tend greatly to increase the cost per unit at which power is supplied.

The excellence of the drive in the case of a steam-driven mill equipped on the most modern lines is, in general, admitted, and the efficiency of transmission by ropes from the engine's pulley to the various lines of shafting being high, and the steadiness of the drive also good, as testified by the facility with which five counts are spun in certain Lancashire districts. If it be asked, then, wherein lies the advantage in the case of a modern mill working constantly at full load of an electric drive, the answer given is, in the increased rate of production possible by the more uniform turning moment and the greater flexibility obtained.

If the subject be treated in divisions, it will be easier to see where the merits or demerits of a particular application lie and to form an idea as to their economic value.

### FLEXIBILITY

It is true that, with the electric motor, the maximum of flexibility is


FIG. 2.—VIEW SHOWING TRANSMISSION ROPE RACE USED IN CONNECTION WITH ENGINE SHOWN IN FIG. 1. MESSRS. HICK, HARGREAVES & CO., LTD., BOLTON

secured. Changes can be wrought easily and expansions effected with convenience, while there is no excuse for transmission losses to a machine which is not in commission. Individual driving permits the running of a machine out of complete disregard to its neighbour, and such sections of machinery whose working is not warranted by the requirements of trade may be shut down.

Then there is the case where, due to want of capital, a complete mill installation cannot be carried out. Here such machinery as could be bought would be laid down, due consideration being taken for future expansion, and the power taken from some public supply. Of course, a greater cost per unit would have to

be paid, but this would prove more economical than running a power plant designed to cope with a maximum on a very light load.

A hot bearing is, unfortunately, not an unknown thing in a textile factory, and its occurrence is attended by appreciable loss when a series of machines is thrown unproductive; but where the electric drive is adopted the mishap is more or less localized, and merely affects individual machines or a lesser group.

### STEADY RUNNING AND ELASTICITY OF REGULATION

To obtain the best quality of work with a maximum rate of production, extreme steadiness of drive, together with a degree of flexibility, is essential. A polyphase motor of the three-phase type is well adapted to these requirements; its uniformity of speed is only subject to changes by the cyclic variation of the prime mover, and with the turbine, with its comparatively continuous flow of steam, these are almost entirely eliminated, and with other forms of steam engine scarcely more in evidence. A feature, however, in which the polyphase motor is deficient is that, without the aid of very cumbersome devices, speed regulation is not possible, and even when attained, only amounts to a radical change. Provision is, consequently, sometimes made for altering the ratio of gear wheels. The direct-current motor, on the other hand, lends itself admirably to a close adjustment of speed regulation, and were it not for its sparking propensities, would be well adapted to the spinning mill, where the machines are run at the greatest speed short of breakages of yarn.

In the textile industries, as elsewhere, the raw material differs in quality from time to time. An inferior class of material demands a different rate of production to that of good quality, and unless the motor is adaptable to circumstances, a maximum output is not ensured.

### RELIABILITY

The reliability of the electric motor is established. It has with success been applied to most classes of work, and under adverse circumstances, both climatic and otherwise.

The alternate-current motor has in electro-textile work proved quite reliable when due consideration has been given to the conditions under which it is required to run.

In shipyards and workshops the direct-current motor may be seen at one instant running light and in the next subjected to overload, and then, perhaps, with reversed rotation through a similar cycle. Is it likely to prove deficient in the textile industries where none of these extremes are brought into focus?

### POWER ECONOMY

It is not disputed that the efficiency of the motor is high, the smaller ones being in some degree less efficient than their larger brethren; but it is questionable whether the efficiency of transmission electrically is better than that by the most modern mechanical means. With scientific lubrication and oils of the most suitable viscosities, etc., adapted to the various conditions, the work lost in friction can be reduced to a very small amount. In an electrical installation in which, say, the individual drives are in excess of the group, an inefficiency is introduced first between the engine and generator, then in the distribution mains, and finally in each individual motor. In direct driving a good deal of belting and gearing is done away with; but where the group system is resorted to, the dispensations do not form so large a factor. Whether the efficiencies of transmission balance each other or not is a controversial question, and both sides have their adherents; on the face of it, it would appear that the electric drive would not effect any further economy in the reduction of power.

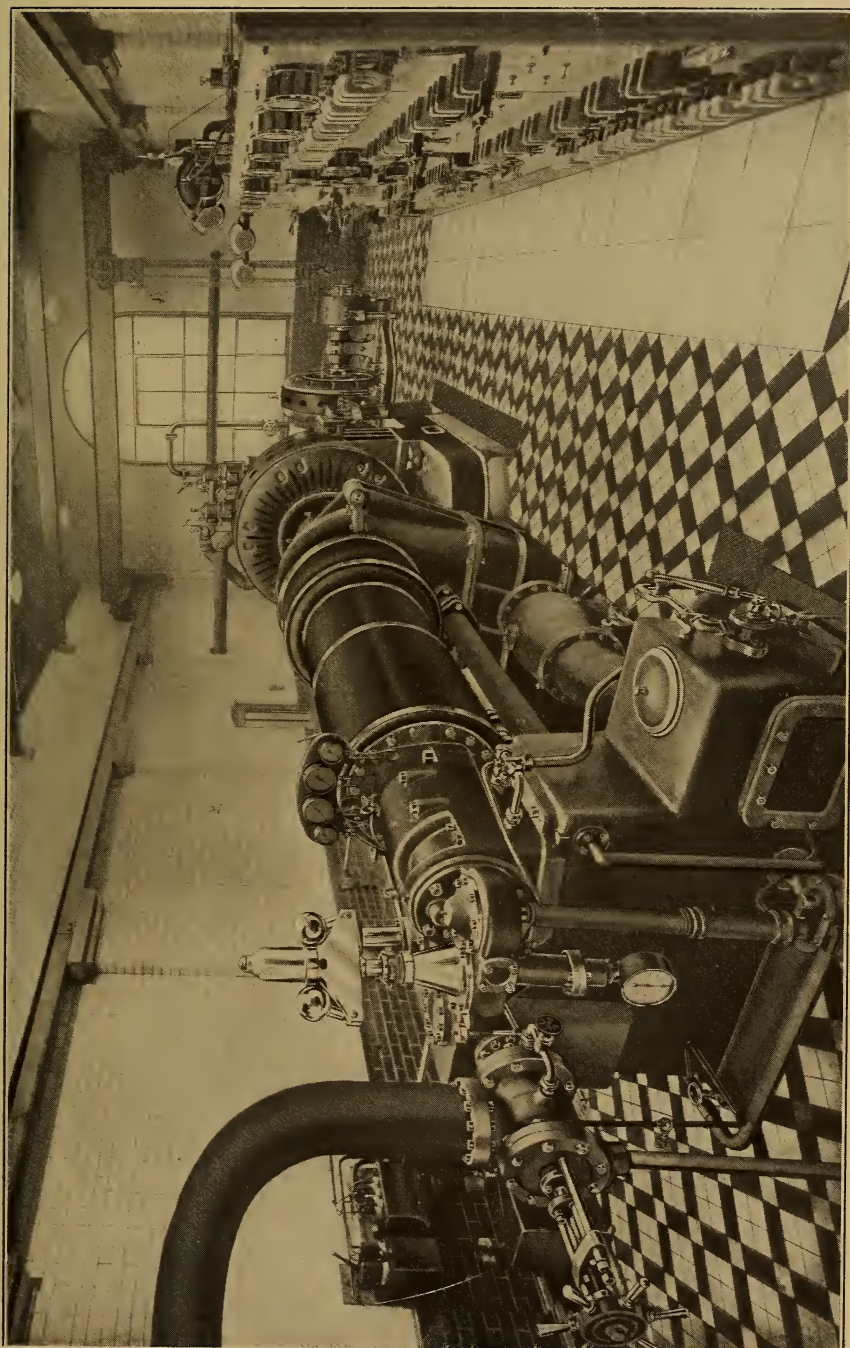


FIG. 3.—TURBO-GENERATOR SET FOR AN ELECTRICALLY OPERATED MILL AS INSTALLED BY MESSRS. DRAKE & GORHAM LTD., MANCHESTER

### MAINTENANCE COSTS, WEAR AND TEAR AND DEPRECIATION

The maintenance costs, which include supervision and working costs, are, with the electric motor, extremely low. The machines are designed to be as fool-proof as possible, and beyond occasional replenishing with oil and dusting, little attention is needed.

Wear and tear do not form any considerable factor. With induction motors the bearings are the only parts subjected to wear, whilst with motors of the direct-current type, the commutator will be found to be durable and the wear of the brushes small.

### ALTERNATING CURRENT OR DIRECT CURRENT

With either of these systems of generation and distribution excellent results can be obtained.

A three-phase system scores over the direct-current in point of simplicity and maintenance charges. It is true that, when subjected to heavy overloads, its effects on the prime generator, and consequently other motors, are pretty considerable; but with the class of work upon which it is employed in the textile industries overloads are more the exception than the rule. Provision is usually made for starting up these motors on no-load, and being put to their work when they have nearly arrived at their synchronous speed, which must be effected without shock, otherwise breakages of yarn, etc., would be the result.

The direct-current motor is well adapted to close adjustments of speed, and enable machines to be run up to the greatest possible speed short of breakages of thread; but on account of commutation, which is not always sparkless, the risk of fire in the fluff-laden atmosphere of a cotton mill is somewhat enhanced.

### GROUP AND INDIVIDUAL DRIVING

In deciding on which of these systems be adopted in a particular case one is guided by certain definite prin-

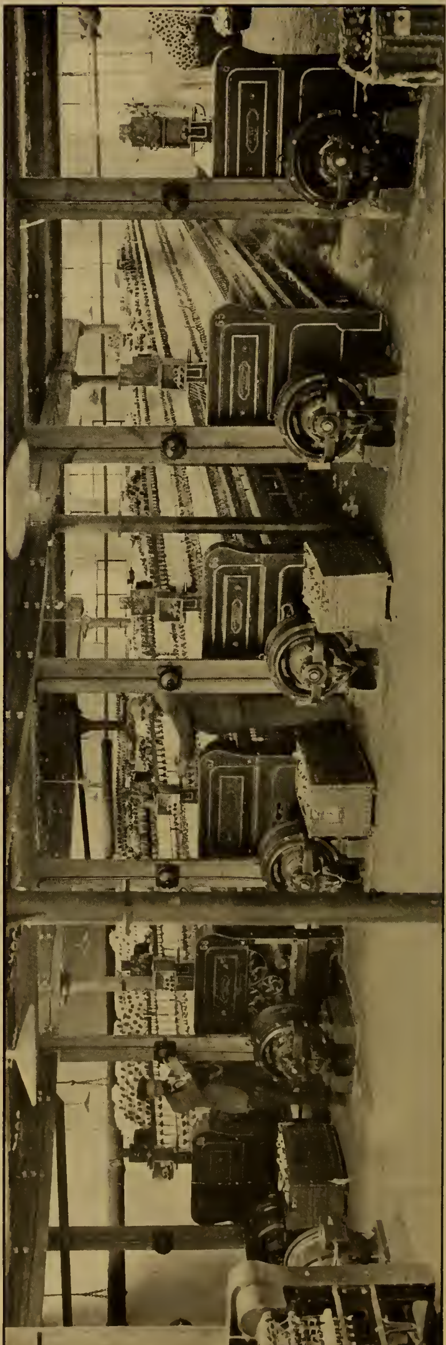


FIG. 4.—DIRECT DRIVEN RING SPINNING FRAMES, SINGLE-PHASE REPULSION MOTORS BY MESSRS. SIEMENS BROS., LTD.

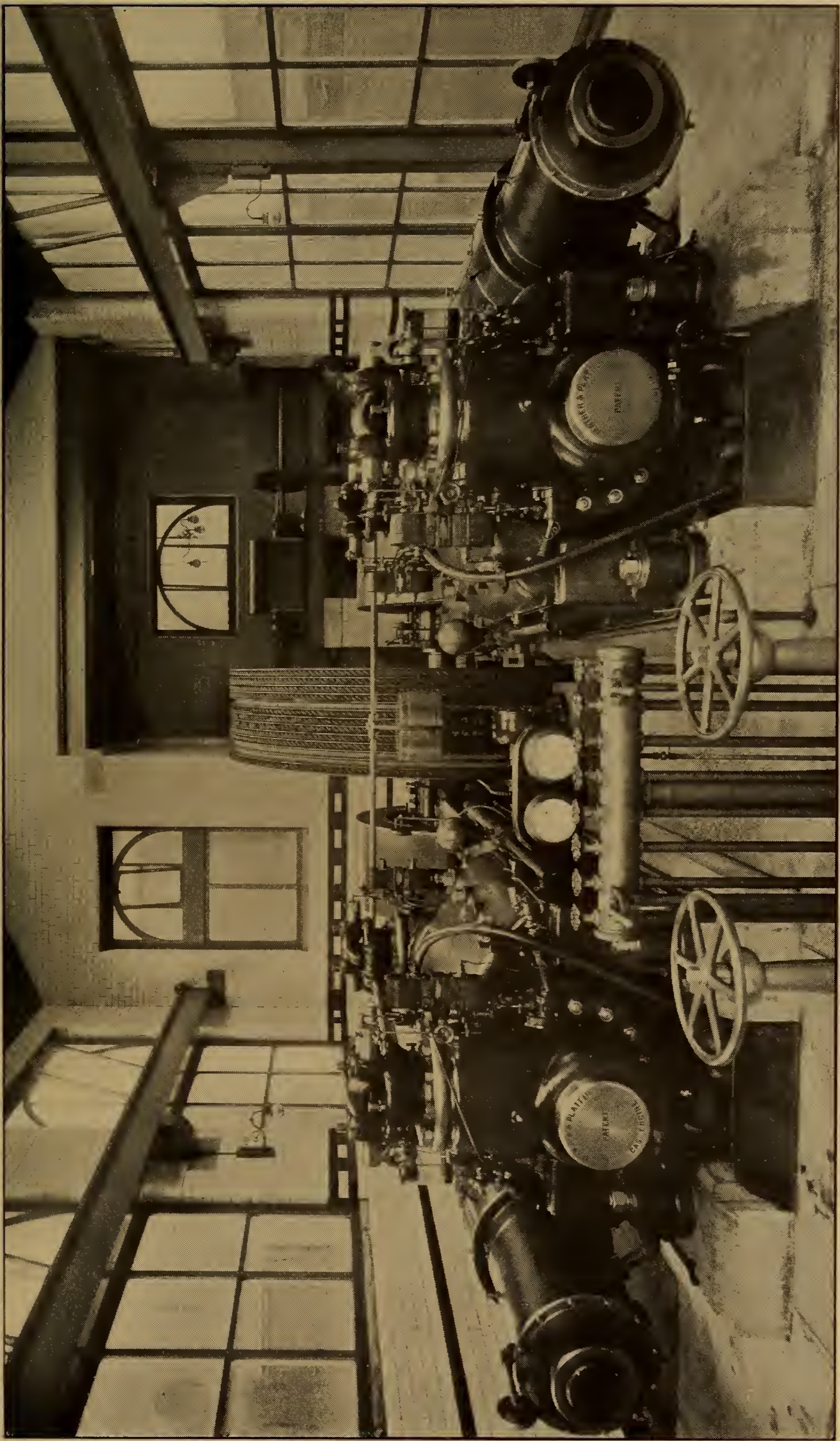


FIG. 5.—TWIN-CYLINDER GAS ENGINE OF 600 BRAKE HORSE POWER INSTALLED BY MESSRS. MATHER & PLATT, LTD., MANCHESTER, IN A SPINNING MILL

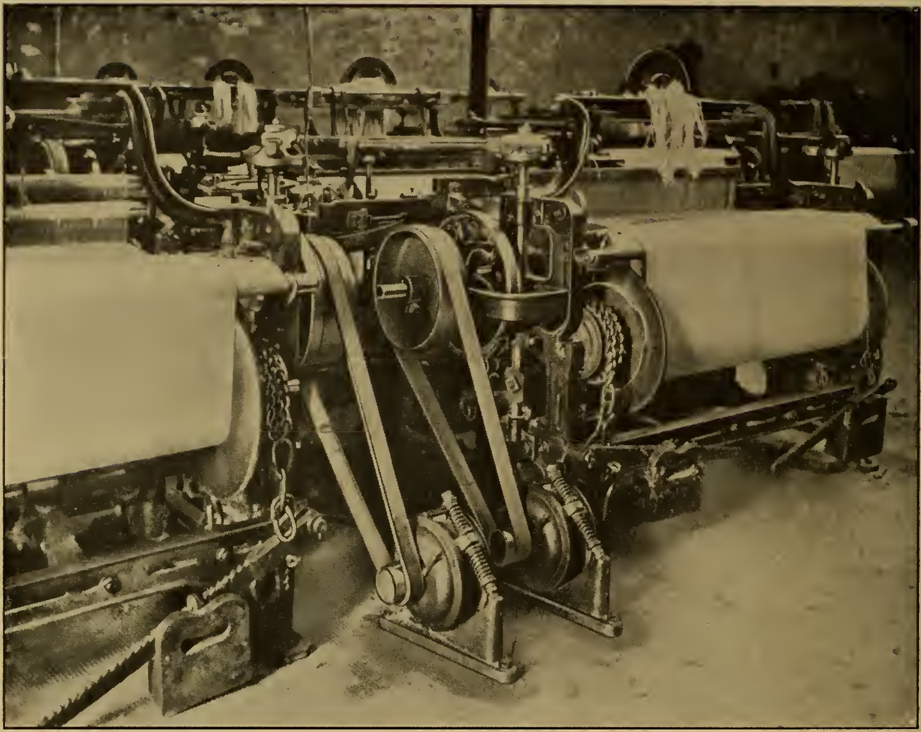


FIG. 6.—LOOMS DRIVEN BY INDIVIDUAL MOTORS, BY SIEMENS BROS., LTD. THE MOTORS ARE CARRIED IN SPRING SUSPENSION, INSURING UNIFORM BELT TENSION

ciples, but the commercial factor enters largely into the question. With some machines the power absorbed is so small that it is not to advantage to make use of an individual drive in each case, especially as these low-rated motors run at a speed which demands the introduction of some form of reducing gear, and are, to an extent, inefficient, to say nothing of the prohibitive cost of an equipment and an increased liability to breakdown. There are, of course, many machines which lend themselves admirably to individual driving, and in such cases the mechanical losses are reduced to a minimum, and belts and gear wheels are, to good extent, dispensed with. But whether the capital outlay on a number of motors for individual driving is warranted ought only to be decided on after deep reflection, for it is a serious matter to have capital sunk in power when it might be more productive elsewhere.

In group driving several machines are operated by one motor; the initial outlay is thus kept down, and a better electrical efficiency is the outcome.

The nature of the load on mule spinning frames renders a group drive imperative, because of the extreme variation throughout a cycle of operations. An individual motor would require to be large enough to cope with the maximum demand, and this would result in low efficiency and load factor; but by grouping the machines and running them as far as possible in definite sequence, the load peaks can be made to level themselves off.

POWER GENERATION

The ideal for power generation in Great Britain lies in the centralization of power plants in close proximity to the coalfields, and in a high-

pressure distribution to mills erected in the vicinity. To the mills alone it would mean a great reduction in capital outlay, and would be attended with advantages of no minor importance. First and foremost their complete power installation would be dispensed with, and appreciable saving in building effected by the elimination of engine houses, foundations, boiler settings, flues, chimneys and rope races. Then with the concentration of power plants, where several thousands of horse-power were being developed, the most economical prime movers could be used, with a stand-by, set for emergency, and nothing spared, either in the main or auxiliary machinery or apparatus, to secure the utmost economy of generation.

It may follow that the gases at present escaping from coke-ovens and blast furnaces will be harnessed to good extent and made to perform useful work, instead of being allowed to be dissipated into space, to the detriment of life and Nature.

In consideration of the recent phenomenal building and equipment of mills, it is doubtful whether the question of centralized power supply will receive serious attention in this decade.

PRESENT SITUATION AND PROBABLE DEVELOPMENTS

Steam-power plants are to-day predominant, and are likely to maintain their prestige in the near future. But there is keen conflict even in its own ranks, the quick-revolution engine with the slow-speed Corliss and piston drop-valve engine, and the steam turbine with all. If steam is to survive the competition of the gas engine, high degrees of superheat will have to be employed, and greater economy will be required in the steam-generating plants. The slow-speed Corliss engine is scarcely adapted to the employment of very high-temperature steam, as the lubrication of the valves becomes a difficult matter, and unless the difficulty is overcome in the near future it is possible that,

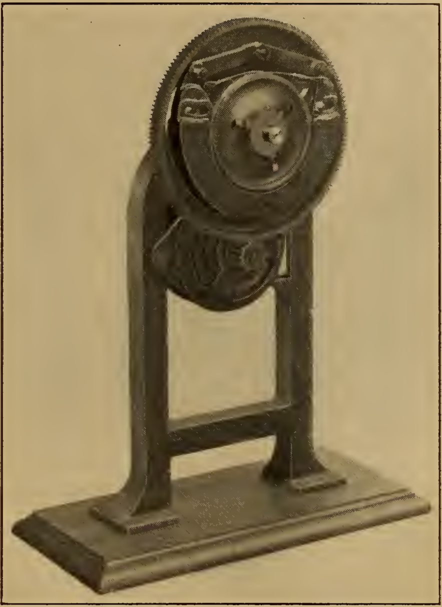


FIG. 7.—CENTRIFUGAL DEVICE TO PERMIT MOTORS RUNNING UP NEARLY TO FULL SPEED BEFORE THE LOOM IS STARTED. MESSRS. SIEMENS BROS., LTD.

for the electric generation of power, it will not receive the consideration that its competitors, the quick-resolution engine and steam turbine, will. On the other hand, the piston drop-valve engine is excellently adapted to superheated steam, and from it great economies may be expected. The writer favours the vertical type of these engines, and is of the opinion that if they could be run at a greater speed it would prove a stubborn opponent to its rivals. During the recent boom in electro-textile work many quick-revolution engines were installed, coupled to both direct-current and alternating-current generators, whilst the turbine was used to equal extent.

The turbo-generating plant has now arrived at a high state of excellence, and possesses many advantages over the reciprocating steam engine. Since the flow of steam through the turbine is practically continuous, there is an almost entire elimination of cycle variation, and the motors, in consequence, run steady. An appre-

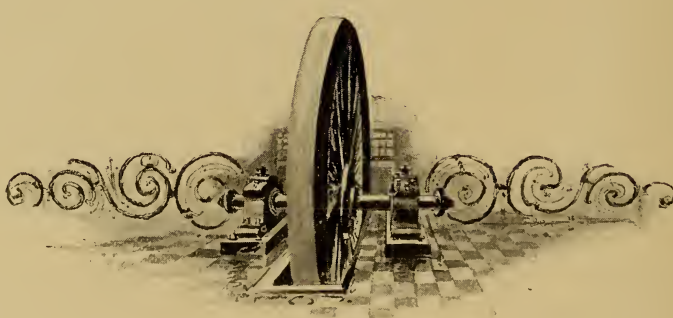
ciable saving is effected in space and foundations, and the use of oil, except for bearings and such like, is unnecessary. Present practice with turbine equipments is to install turbo-alternators in duplicate, each of such power to deal with half the load under normal conditions with a maximum of efficiency, and capable of 100 per cent., with an increase in steam consumption of from 10 to 12 per cent. With this arrangement, although the capital expenditure is somewhat heavier, a greater immunity from breakdown is secured.

It is recognized that the gas engine operating on producer gas is the most economical source of power from coal that we have; but until greater reliability and steadier running are secured, it is not likely seriously to challenge the predominance of the steam-power plant. The issues betwixt them resolve themselves into reliability and freeness of cyclic variation for the gas engine and efficient combustion and economy of steam generation for the steam plants.

Great advancements are being made with gas-engine units, and in the near future it is possible that producer plants, at present in a transitional stage, will be seen operating quite satisfactorily on low-grade bituminous fuels.

The efficiency of combustion and steam generation even with our modern boiler plants is not satisfactory, only some 60 per cent. of the total heat developed being transferred to the water in the boiler. A solution to the difficulty seems to be offered in the firing of boilers of the water-tube type by producer gas, the products of combustion being used for pre-heating the air used for combustion.

Much could be done in this direction if engineers would turn their energies to the subject and apply themselves with equal industry as they have done to the development of the turbine and electrical machinery.



# Current Topics

IN engineering, as in many other matters, the influence of precedent counts for much. The practice of launching a vessel lengthwise, for example, has seemed perfectly natural to all dwellers by the ocean and on the large streams near the sea where much of the important shipbuilding of the world is carried on. As a matter of fact, it is natural to start a vessel into the water in the same direction which it is expected thereafter to follow. So it seems to the dweller by the coast to be a rather unusual thing to see a ship allowed to slide into the water sidewise, and one can hardly witness a side launching without expecting the vessel to bob about a great deal, even if it does not exactly "turn turtle." Of course, it is a matter of record that the Great Eastern was pushed sidewise into the Thames, but that ship was so different from anything else which had preceded that it did not seem strange for it to be launched after a manner of its own.

The same reason which led to the sidewise launching of the Great Eastern, that is, lack of water room of suitable depth, has doubtless been the reason for the general practice of sidewise launches in the shipyards supplying the vessels for service on the Great Lakes of America. It was therefore a most interesting matter to many of the members of the American Society of Mechanical Engineers, at the recent meeting at Detroit, to witness the sidewise launch of a vessel of more than 10,000 tons displacement, and to see how simply and accurately the whole operation was conducted.

We expect, in a forthcoming article, to give some illustrations of this most convenient method of transferring vessels from the land of their construction to the waters where they are to pass their active careers, and it may appear to others, as it does to the dwellers by the Great Lakes, a matter for surprise that shipbuilders everywhere do not follow the simple and convenient plan of constructing the hulls by the side of narrow slips, and letting them make their first acquaintance with the water broadside on.

*   *   *   *

Several months ago there was described and illustrated in these pages, in an article by Mr. P. J. McKeon, the general arrangement and operation of the high-pressure water supply for fire service which has been installed in certain parts of New York City. Already this service has proved its value and effectiveness, and both at the sea-shore resort of Coney Island and in the commercial

parts of the city serious fires have been fought and kept in check by the use of the high-pressure service. The effective work of the high-pressure service appears in the fact that at the Coney Island fire, although steam-fire engines responded to the call, not one of them was required, while each of the hydrants of the high service was able to maintain pressure upon six lines of hose, providing all the water which could be effectively used, and preventing the spread of the flames in a most dangerous and difficult location.

In other cases the efficiency of the system has been clearly demonstrated, the salt-water service having been led through hose to water towers distant as much as 500 feet from the hydrants.

With such experiences in mind it seems as if the high-pressure system must supersede the portable fire engine, at least in large cities situated as New York, in locations in which abundant water supply is available.

* * * *

We desire to remedy an omission which occurred in the article on "Tall Building Construction in New York," in our issue of last month, with reference to the construction of the Hudson Terminal Buildings. The author, Mr. C. H. Hughes, mentioned the methods adopted in the construction of the foundations and two lower floors of this important structure, but neglected to state that all except these two lower floors were built in the Roebling System of reinforced concrete. The Roebling system of fireproof construction is especially adapted to buildings of this nature, and has been extensively employed in many important structures, and the development of the system by the Roebling Construction Company, of New York, is a notable example of the success of reinforced-concrete construction in modern tall buildings.

An interesting feature of the Detroit meeting of the American Society of Mechanical Engineers was the fact that at the same time and in the same place there was held a convention of the Society for the Promotion of Engineering Education. It had been held, and in some instances with justice, that there is not a sufficiently close relation between the men who are in charge of technical education and those who are actually doing the engineering work of the world. Such gatherings as those which have recently been held, however, go far to demonstrate that the professors and the practicing engineers are working well together, and that technical training is entering very effectively into the development of engineering work and practice.

As positive evidence that the education received in the engineering schools in the United States is acceptable to the practicing engineers of the country it may be noted that even in dull times the graduates of the schools are able within a brief time to obtain positions in engineering works, while in periods of prosperity there is often a greater demand for graduate students than can be immediately supplied.

One of the indications of the development of engineering practice appears in this very change in the relation of the technically trained man to the shop and its work. With modern tools, methods and systems, the operative force of an engineering works is becoming differentiated into the operative and the directing classes, and many things formerly left to the judgment of the old-time skilled mechanic are now determined positively by measurement, test and record, removing in great measure the former uncertainty, and giving the manufacturer the benefit of the latest advances in science, while at the same time increasing his output and lowering his costs.

# ROBERT FORRESTER MUSHET

A BIOGRAPHICAL SKETCH

IN view of the recent developments in the manufacture of tool steels, and especially the so-called high-speed steels, it may be of interest to consider the work which led up to these developments, the achievements of a man who passed away nearly twenty years ago, after a long life devoted almost wholly to improvements in the manufacture of steel.

Robert Forrester Mushet, who was born at Cheltenham in 1811, was the youngest son of Mr. David Mushet, himself an earnest and effective worker in the development of British iron and steel industries. The labours of the elder Mushet have been described as being among the most fruitful in results to the British iron industry in the early years of the nineteenth century. The most important of these results was undoubtedly the discovery of the blackband ironstone, the foundation of the Scottish iron trade, while his researches into the manufacture and properties of steel threw much light upon what was at that time a very obscure subject. David Mushet introduced a process for the manufacture of cast steel which was long carried on at Sheffield.

With such an example before him, Robert Forrester Mushet early turned his attention to the production of crucible steel, and soon became a worthy follower of his father. Establishing a small experimental works at Coleford, in the Forest of Dean, he continued his investigations, especially upon the influence of various alloys upon the properties of tool steels, and by the use of tungsten ~~and~~ or wolfram he succeeded in producing a special steel of valuable qualities for engineers' cutting tools. In connection with this work he also improved the crucibles used in his investigations, and found that, by adding a certain proportion of china clay to the material, he was able to make crucibles capable of resisting high temperatures for a longer time than formerly. The result of these experiments was the well-known Mushet special tool steel, the original of all "air-hardening" tool steels which have followed and the undoubted precursor of the modern "high-speed" steels developed by Taylor & White and their followers.

In the meantime another investigator was engaged in the development of a process for the manufacture of steel upon a large scale, and in March and May, 1856, Henry Bessemer took out his famous patents for the production of steel from cast iron by burning out the excess of carbon by forcing a blast of air through the molten metal. Although the Bessemer process was theoretically complete, it was far from being so in practice at this time. By stopping the blast and turning down the converter at the moment when the carbon content had reached the desired proportion it was proposed to make steel, but this was found to be very difficult of accomplishment. Bessemer was endeavouring to remedy this practical defect in his process, and was experimenting with metallic manganese when, on September 22, 1856, Mushet obtained a patent for the addition of molten spiegeleisen to Bessemer's decarburized steel while still in the liquid state. It was this invention of Mushet's which rendered the Bessemer process complete. The operation, as then adopted and

used ever since, was to decarburize the metal completely by the blast in the converter and then to add a given proportion of carbon in the condition existing in molten spiegeleisen. In this way the proportion of carbon was placed completely in the control of the operator and a definite and predetermined product made without any uncertainty.

It was for this invention that the Iron and Steel Institute in 1876 awarded Mr. Mushet the Bessemer medal. In this connection probably the best comment which can be made upon Mushet's service to the art of the manufacture of steel is that included in the remarks of the late Mr. William Menelaus, the president of the Institute, upon the occasion of the award.

Mr. Menelaus said that it would be needless to such an assemblage to dilate at any length on what the iron and steel trades of England owed to Mr. Mushet, himself the son of a man who was one of the first to apply scientific research to the ordinary operations of iron works. The son, Mr. Robert Mushet, through his whole working life walked in the footsteps of his father, and pursued the same investigations that his father, through a long life, had been engaged upon in connection with the manufacture of iron, and more particularly of steel, trying to cheapen its production and improve its quality. It was needless to inquire very particularly what success attended Mr. Mushet's attempts to improve old processes, because they were all overshadowed by the beautiful invention of the spiegeleisen process, and it was upon that ground that the Council resolved to pay Mr. Mushet the compliment they did. He thought that they would agree with him that the application of spiegeleisen in the way it was done to Mr. Bessemer's invention was one of the most elegant, as it certainly was one of the most useful, inventions ever made in the history of metallurgy, and he thought it would be conceded for that alone, if for nothing else, Mr. Mushet well deserved the compliment they were about to pay him. It was an invention which was worthy of being associated with the great invention of Mr. Bessemer. The two inventions would go down together; in fact, one was the complement of the other, and he thought he was right in saying that no man in the room would be better pleased than his friend Mr. Bessemer that the Council had resolved to pay that compliment to Mr. Mushet. He thought it was a fit and seemly thing that the medal instituted by Mr. Bessemer should compliment the man who had made what he thought was a really brilliant invention. It had made the invention of Mr. Bessemer perfect, and probably would be used in England as long as Bessemer metal was made.

Mr. Mushet continued his investigations in the production of special tool steels, taking out thirteen patents in this connection between March, 1859, and December, 1861, some of these having especial reference to the use of titanium alloy steels. During the latter years of his life ill health compelled his retirement from active life, and he passed away on February 6, 1891, in his eightieth year. As he followed in the special line of work initiated by his father, so he was succeeded at Sheffield in the production of special steels by his two sons, Henry Mushet and Edward M. Mushet.

J. STEPHEN JEANS

(See page 480.)

# CASSIER'S MAGAZINE

VOL. XXXIV SEPTEMBER, 1908 No. 5


## METHODS OF TESTING MATERIALS FOR HARDNESS

By J. F. Springer

THAT which distinguishes steel from iron is its carbon content. It is the presence of this constituent that renders it possible to impart that strength, rigidity and hardness which make of steel by far the most important material in the service of man. It is scarcely too much to say that our present civilization would scarcely be possible apart from this metal. If our bridges, machines, buildings, automobiles, railway rails and a thousand and one indispensables of modern existence were made of iron or some other substitute, our present mode of life would be impossible. We would be back in some mechanical dark age. But certain of the most important steps in steel manufacture have occurred during very recent years, especially in this matter of hardness. It was fairly easy to make an exceedingly hard material by heating a high-carbon steel to a very considerable heat and then chilling suddenly. But this process, while it produced an extremely hard substance—as witness our files—was accompanied by the very grave disadvantage that it gave rise to excessive brittleness. What was gained in hardness was lost in toughness. However, the toughness could be partially restored by tempering, at some loss of hardness. But the alloy steels have been meeting this old-time difficulty by enabling the carbon content to be increased without the accompanying disadvantage of great brittleness upon being hardened. That is to say, it is now possible to have steel both hard and tough. Moreover, with the varieties of alloys known as the high-speed steels, it is possible to have steel both hard and hot, so that the cutting edge is maintained although the steel has become heated. These are remarkable advances, and mark an epoch in the age of steel.

Now hardness depends largely upon the carbon content. But it is also dependent upon the processes of heating, cooling, etc.; that is, upon its handling. So it comes about that this extremely important property of steel cannot be determined with certainty from a chemical analysis and consequent determination of the percentage of carbon. In fact, there has been, until recently, no very reliable commercial method of determining with any precision the degree of hardness possessed by steel articles. Thus, we almost seem to have entered upon an epoch of wonderful steels without an accurate and simple method of testing them for their hardness. But this defect would now appear in process of correction. There are, in fact, two or three methods claiming attention.

The oldest of these modern methods to which we refer is the Brinell method. By this method a steel ball is pressed upon the surface of the steel to be tested with great force. By measuring the depth or diameter of the permanent indentation and making use of the figure thus obtained in connection with the values of the pressure and diameter of the steel ball, a number may be calculated which has been considered more or less proportional to the degree of hardness.

In Professor Brinell's method, the so-called hardness number is obtained by dividing the pressure, expressed in kilograms, by the area of the spherical indentation in square millimeters. If $K$, $A$ and $H$ represent respectively the pressure, area and hardness, we have thus:

$$H = \frac{K}{A}$$

Now $A$ may be computed either from a measurement of the diameter of the indentation or from its depth. In the diagram $r$ is the radius of the ball,

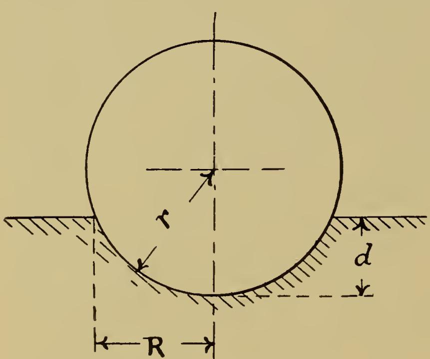



DIAGRAM OF BRINELL TEST

$R$ the radius of the indentation and $d$ its depth. Now $A$ is the area of a zone of one base and is consequently equal to the product of the circumference of a great circle by the depth of the zone. That is,

$$A = 2\pi rd$$

This gives,
$$H = \frac{K}{2\pi rd} \qquad (1)$$

which is perhaps the simplest formula for the calculation of the Brinell numbers. If, however, it seems more advisable to measure the *diameter* of the indentation, we may transform this formula by remembering that $R$ is the mean proportional between the segments of the diameter perpendicular to it. That is,

$$R^2 = d\,(2r - d)$$

This yields, $d$ being less than $r$,

$$d = r - \sqrt{r^2 - R^2}$$

Replacing the value of $d$ in (1) by that obtained, we get

$$H = \frac{K}{2\pi r\,(r - \sqrt{r^2 - R^2})}$$

This is an objectionable form in which to leave this formula, as the errors arising from decimal calculation of the denominator will tend to be magnified in the final result. However, by multiplying both numerator and denominator by $r + \sqrt{r^2 - R^2}$, we obtain

$$H = \frac{K\,(r + \sqrt{r^2 - R^2})}{2r \times \pi R^2} \qquad (2)$$

This is a fairly convenient form. If desired, $\pi R^2$ may be determined by means of an integrating instrument by running the needle around the edge of the indentation and thus ascertaining the area of the circle whose radius is $R$. But as this would introduce a new source of error, it is not to be commended. If $K = 3000$, $r = 5$, $R = 2$, we calculate the Brinell hardness number thus:

$$H = \frac{300\,(5 + \sqrt{25 - 4})}{\pi \times 10 \times 4} = \frac{28747.8}{125.664} = 229$$

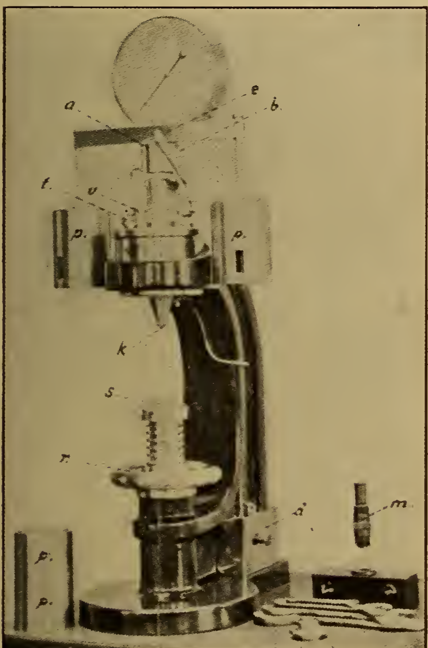
That formula (1) is much easier to calculate may readily be seen by applying it to the same problem. The value of $d$, ascertained by micrometric methods, is found to be .4174. Substituting this value in (1) we get

$$H = \frac{3000}{2 \times \pi \times 5 \times .4174} = \frac{3000}{13.113} = 229$$

This method would appear better, too, from the consideration that it seems easier to measure the *depth* of the de-

pression with precision rather than its diameter.

If many numbers have to be calculated, the value of $2\pi r$ may be determined once for all, or even the value of $\dfrac{K}{2\pi r}$. If the latter is done, then it simply remains to divide this constant value by the depths as they are severally determined. Now a ball of any desired size may be used, but Prof. Brinell recommends that having a diameter of 10 mm. (= 25/64 inch).



BRINELL HARDNESS-TESTING MACHINE

The machine shown in the illustration has been devised to perform the necessary operations. The pressure is applied by a hydraulic press operating downwards. The steel ball, *k,* is fixed to the piston of the press. The table *s* is controlled vertically by the wheel *r.* The specimen to be tested is placed on *s.* It is important that the upper surface shall be horizontal. To effect this in special cases the table *s* may be tilted. The wheel *r* is turned in order to elevate the specimen and bring it into contact with *k.* The valve *v* is closed, thus separating the cylinder of the press from the oil cistern. The press is now operated by hand until the indicator shows that the required pressure, say 3000 kilogrammes, has been attained. If the specimen is iron or steel, the pressure is maintained for fifteen seconds; if a softer metal, for perhaps half a minute. It is then discontinued, the valve *v* is opened and the wheel *r* reversed. A spring within the cylinder returns the piston to its position and the oil to its reservoir. The special microscope *m* is now used to measure the diameter of the indentation. It is claimed that it is possible to determine the diameter within 1/20 mm. ( = .002″). With a properly-arranged micrometric screw, it would seem that it should be possible to measure, not the diameter, but the depth to .0001″.

But whichever method is adopted, the reading will enable the corresponding Brinell hardness number to be computed. If a considerable amount of testing is done, it will be well to have a table showing the hardness numbers corresponding to a more or less extended range of depths or diameters. (See page 390.)

The Brinell method, or rather a modification of that method, has been employed in Europe by Mr. Sandberg in testing steel rails. The size of the ball used was 19 mm. (= ¾ inch) and the pressure amounted to 50,802 kilograms (= 50 long tons). These are not real departures from the Brinell method. But Mr. Sandberg, instead of dividing the pressure by the *area* of the spherical surface of the concavity, apparently divides the *volume* of the depression by the pressure. This would result in the numbers *decreasing* with the decrease of hardness. Consequently, it seems better to divide the pressure by the volume displaced and thus derive a series of numbers resembling the ordinary Brinell numbers. However, the two series will vary at different rates, seeing that areas vary as the squares of the radii while volumes

REFERENCE TABLE—FOR BRINELL METHOD.
PRESSURE = 3000 KILOGRAMMES.

| Measurement of Indentation, mm. | Hardness Numbers. (1) If Measurement is Depth. | Hardness Numbers. (2) If Measurement is Diameter. | Measurement of Indentation, mm. | Hardness Numbers. (1) If Measurement is Depth. | Hardness Numbers. (2) If Measurement is Diameter. |
|---|---|---|---|---|---|
| 1.00 | 955 | | 3.60 | 265 | 286 |
| 1.05 | 909 | | 3.65 | 262 | 277 |
| 1.10 | 868 | | 3.70 | 258 | 269 |
| 1.15 | 830 | | 3.75 | 255 | 262 |
| 1.20 | 796 | | 3.80 | 251 | 255 |
| 1.25 | 764 | | 3.85 | 248 | 248 |
| 1.30 | 735 | | 3.90 | 245 | 241 |
| 1.35 | 707 | | 3.95 | 242 | 235 |
| 1.40 | 682 | | 4.00 | 239 | 228 |
| 1.45 | 659 | | 4.05 | 236 | 223 |
| 1.50 | 637 | | 4.10 | 233 | 217 |
| 1.55 | 616 | | 4.15 | 230 | 212 |
| 1.60 | 597 | | 4.20 | 227 | 207 |
| 1.65 | 579 | | 4.25 | 225 | 202 |
| 1.70 | 562 | | 4.30 | 222 | 196 |
| 1.75 | 546 | | 4.35 | 220 | 192 |
| 1.80 | 531 | | 4.40 | 217 | 187 |
| 1.85 | 516 | | 4.45 | 215 | 183 |
| 1.90 | 503 | | 4.50 | 212 | 176 |
| 1.95 | 490 | | 4.55 | 210 | 174 |
| 2.00 | 477 | 946 | 4.60 | 208 | 170 |
| 2.05 | 466 | 898 | 4.65 | 205 | 166 |
| 2.10 | 455 | 857 | 4.70 | 203 | 163 |
| 2.15 | 444 | 817 | 4.75 | 201 | 159 |
| 2.20 | 434 | 782 | 4.80 | 199 | 156 |
| 2.25 | 424 | 744 | 4.85 | 197 | 153 |
| 2.30 | 415 | 713 | 4.90 | 195 | 149 |
| 2.35 | 406 | 683 | 4.95 | 193 | 146 |
| 2.40 | 398 | 652 | 5.00 | | 143 |
| 2.45 | 390 | 627 | 5.05 | | 140 |
| 2.50 | 382 | 600 | 5.10 | | 137 |
| 2.55 | 374 | 578 | 5.15 | | 134 |
| 2.60 | 367 | 555 | 5.20 | | 131 |
| 2.65 | 360 | 532 | 5.25 | | 128 |
| 2.70 | 354 | 512 | 5.30 | | 126 |
| 2.75 | 347 | 495 | 5.35 | | 124 |
| 2.80 | 341 | 477 | 5.40 | | 121 |
| 2.85 | 335 | 460 | 5.45 | | 118 |
| 2.90 | 329 | 444 | 5.50 | | 116 |
| 2.95 | 323 | 430 | 5.55 | | 114 |
| 3.00 | 318 | 418 | 5.60 | | 112 |
| 3.05 | 313 | 402 | 5.65 | | 109 |
| 3.10 | 308 | 387 | 5.70 | | 107 |
| 3.15 | 303 | 375 | 5.75 | | 105 |
| 3.20 | 298 | 364 | 5.80 | | 103 |
| 3.25 | 294 | 351 | 5.85 | | 101 |
| 3.30 | 289 | 340 | 5.90 | | 99 |
| 3.35 | 285 | 332 | 5.95 | | 97 |
| 3.40 | 281 | 321 | | | |
| 3.45 | 277 | 311 | | | |
| 3.50 | 273 | 302 | | | |
| 3.55 | 269 | 293 | | | |

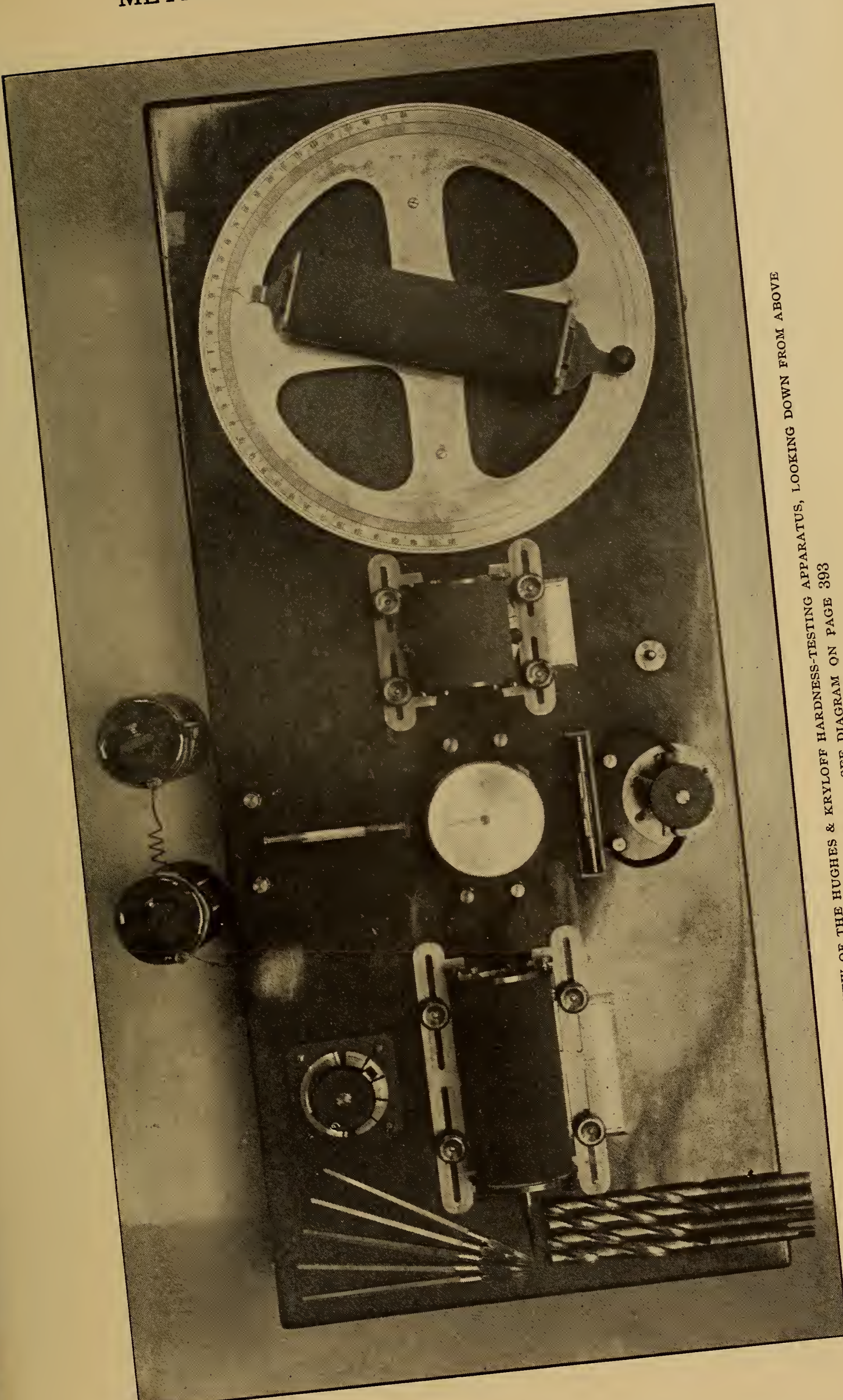
vary as the cubes. The reversed Sandberg numbers will therefore disclose a more rapid change than those of Brinell. Thus in a comparative table given by Messrs. Stead and Greville-Jones, the reversed Sandberg numbers show a variation from 457 to 82, corresponding to a change from a depth of 2 mm. to 5 mm., while the Brinell numbers for the same change in depth show only a variation from 425 to 170. The load (50,802 kg.) and ball (19 mm.) are the same in both cases.

The second modern method utilizes the electric current. It is claimed that the strength of the magnetization *varies with the hardness,* provided other things are equal. This is most important. It is the essential principle underlying this new method, which is the result of the labours of Prof. D. E. Hughes and Col. Ivan Kryloff. Prof. Hughes lays down as fundamental principles for iron and steels of all descriptions the following two laws:

1.—The magnetic capacity is directly proportional to the softness or molecular freedom.

2.—The resistance to a feeble external magnetic force is directly as the hardness or molecular rigidity.

What is meant by "magnetic ca-



PLAN VIEW OF THE HUGHES & KRYLOFF HARDNESS-TESTING APPARATUS, LOOKING DOWN FROM ABOVE

SEE DIAGRAM ON PAGE 393

pacity" will appear as we proceed. The apparatus is shown as viewed from above. It consists of a board upon which are mounted the various elements. At the rear are two binding posts, by means of which connection may be made with a dry battery or other source of an electric current. This current should be constant and of 3 to 8 volts. From these posts two circuits diverge. One current passes, in the direction indicated by the arrow, to the commutator 5. From this it proceeds to the coil 1. Passing through this it emerges and proceeds to a second coil 2. After traversing this it passes again to the commutator 5. It next passes to the rheostat 6, from which it continues to the battery 9. A second circuit passes from the right-hand binding post, in the direction indicated by the arrow, to the coil 7. After traversing this it emerges and passes to the battery 9. Between the coils, or solenoids, 1 and 2, is arranged a magnetic compass. This has a removable needle. The pivot upon which the needle turns is depressable to permit the oscillations of the needle being quieted. The button controlling the depressing arrangement is seen just to the right of the commutator in the plan, to which the opposite diagram corresponds. The compass is protected by a glass cover from external disturbance of the atmosphere, etc. Above and below the magnetic needle are seen levels, one arranged longitudinally by means of the slots and screws seen in the engraving. The coil to the extreme right is rotatable about an axis perpendicular to the plane of the board. Both the magnetic needle and this coil are furnished with graduated scales to determine their deviations from a zero position.

To make the instrument ready for use, the board is leveled by means of the two levels, and so arranged that one end of the magnetic needle is on the zero of its scale. This is accomplished before any current is passed through the various coils. Upon turning on the current—the commutator being set to direct the current now this way, now the other—the needle will probably be deflected. This is due to the inequality of the influences exerted by induction from coils 1 and 2. By adjusting them longitudinally, this deviation may be corrected. If now a piece of unmagnetized steel be placed in a suitable holder, say of brass, and inserted in the solenoid 1, the magnetic needle will be deflected. All this time the coil 7, containing an electro-magnet, is pointing to its zero; that is, is occupying a position exactly parallel to the position of the needle before deviation. By rotating this coil, its currents may be made to set up a corrective influence tending to nullify the influence proceeding from the newly-made electro-magnet in 1, which has caused the deviation of the needle. By continuing the rotation of 7, a point will finally be reached where the correction of the needle's deviation will be complete. The amount of rotation required to effect this is noted on the scale, which is graduated to ½ degrees to the right and left of the zero position. The coil 7 is now returned to its normal position. By means of the commutator, the current is now reversed. The magnetic needle is deviated in a direction the opposite of that observed before. This will require for its correction a deflection of the coil 7 in a direction opposite to its former rotation. The amount of this present deflection is now noted and added to the former amount. This total is termed the "magnetic capacity" of the piece of steel in the solenoid 1.

If the form, size and chemical constitution of the piece of steel being tested remain the same, the magnetic capacity will be found to vary with different specimens and to give, it is thought, a very accurate indication of the degree of hardness; the softer the tested piece, the greater the magnetic capacity.

Now there are a great many different steels and a great many different forms and sizes. All these differences are factors affecting the magnetic currents. So that, to determine the

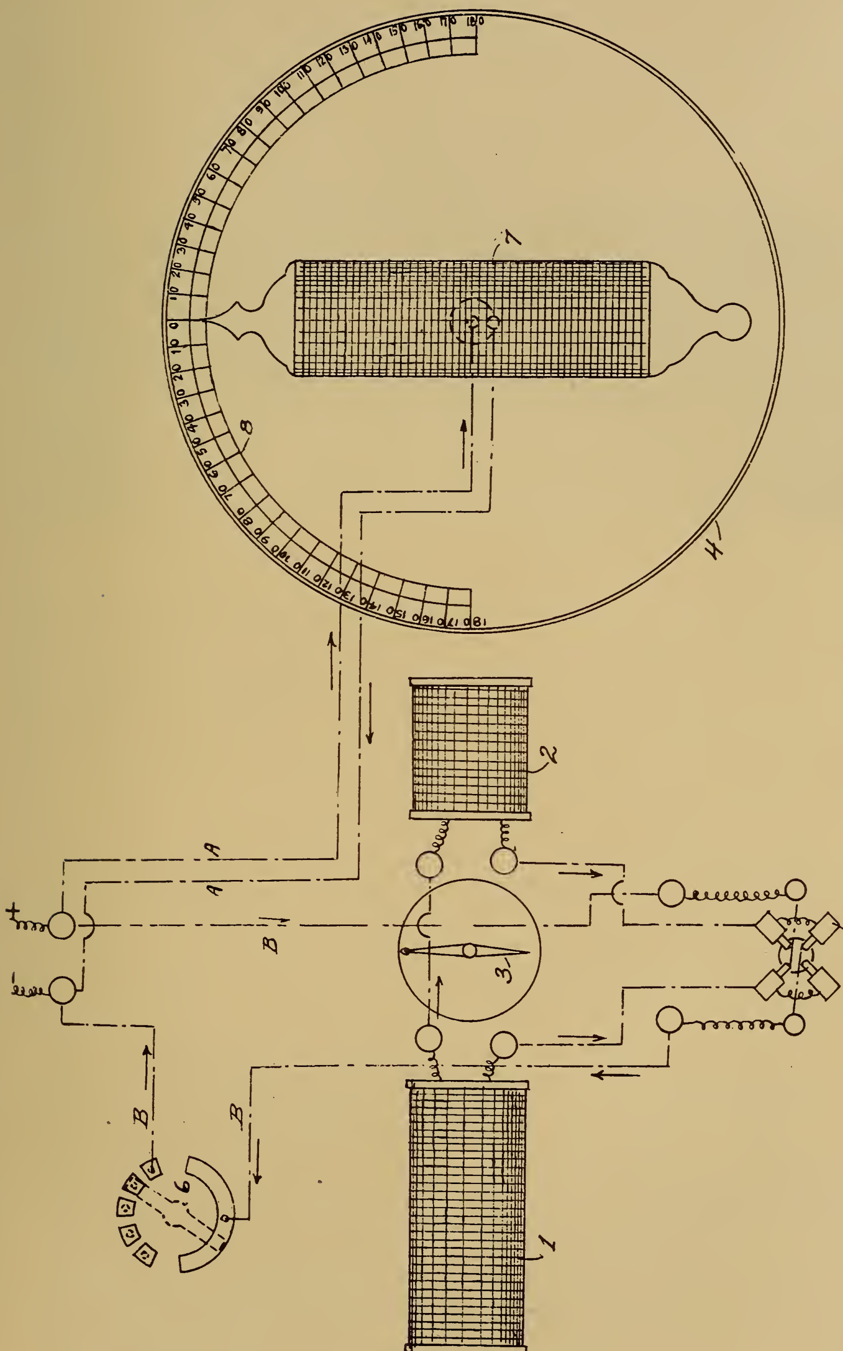
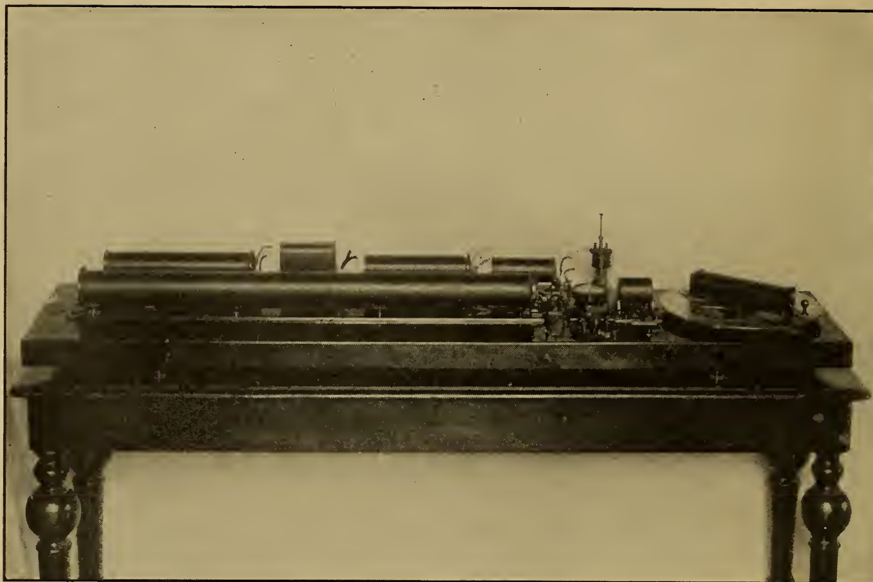



DIAGRAM OF CONNECTIONS OF HUGHES & KRYLOFF ELECTRICAL DEVICE FOR TESTING HARDNESS

SEE PLAN ON PAGE 391



THE HUGHES & KRYLOFF APPARATUS ARRANGED FOR TESTING THE HARDNESS OF GUN PARTS

hardness, it is well in practice to establish a standard and observe its magnetic capacity, and then compare with this the magnetic capacity of a piece of steel precisely like the standard, in form, size and chemical constitution. If the numerical indication of the magnetic capacity is found to be the same, it agrees in hardness; if less, it is harder; if greater, it is softer. By this means the numerical value desired having once been determined for certain work made of certain material, it is scientifically possible to produce an output of uniform hardness.

Various forms of this apparatus are shown—as adapted to the testing of gun barrels and other parts. One form is suited to the testing of rails for railway service, one end being inserted, or a short length.

An important application of this instrument is to the determination of the carbon percentage itself. It may be done in the following manner and for the following reasons: If two pieces of steel, otherwise alike, differ only in their carbon content, then this carbon content is said to be directly proportional to the hardness. Let the two pieces, alike in form and size, be annealed under the same conditions, and then tested for hardness. The results will indicate the relative carbon contents. In this way the carbon percentage is said to have been ascertained within approximately .025 per cent.*

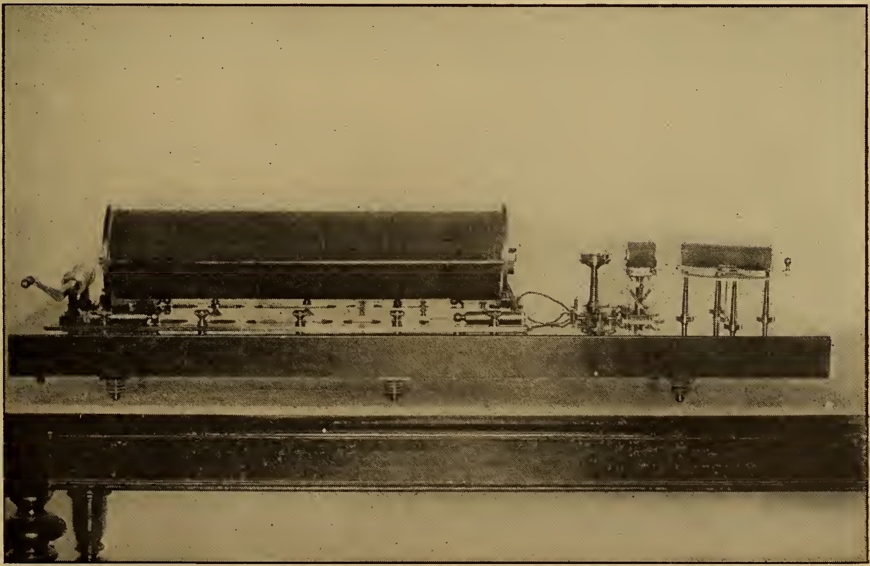
We come now to a third process, also recent. In this the principle relied on is entirely different from the fundamental theorems of the former methods. Here it is assumed that hardness is proportional to the energy of recuperation *when the limit of elasticity has been exceeded.* Without discussing the validity of this principle at the present moment, we consider its application in this new instrument called the scleroscope. With this a blow is struck of such considerable force that the limit of elasticity is exceeded. In fact, the hammer used for the harder substances makes an impact calculated at 75,000 pounds to the square inch. The limit of elasticity for the hardest steels is thus exceeded and a permanent indentation

*This instrument is sold in the United States by Schuchardt & Schutte, 136 Liberty Street, New York City.

made. However, this is so minute as to be generally unobjectionable. As the elastic limit is exceeded, the rebound comes short of equalling the fall. But this rebound measures the energy of recuperation. In the scleroscope, the total fall—about ten inches—is divided into 140 equal graduations and the rebound measured against such a scale. Of course no substances disclose a hardness of 140, as that would indicate that the energy of rebound was equal to that of impact. This could not be the case as long as the requirement is satisfied that the blow must produce a permanent indentation; that is, that it must cause the elastic limit to be passed.

The upright glass tube serves to guide the falling hammer. This tube is about ten inches in length and is held in position by the vertical rod seen to the left. The rod to the right of the tube swings freely from its upper end, and is, in fact, a plumb rod. Its obvious use is to enable the operator to determine whether the tube is really in a vertical position. The little hammer is cylindrical in its body, but pointed on its lower end. It is allowed to fall freely. It is returned to the upper portion of the tube by means of a vacuum formed through the agency of the rubber bulb seen at the top of the instrument. Arrived at the top, the hammer is retained in position by suitable catch. To drop the hammer, the hook, seen near the top and to the left, is pressed down and the lower bulb compressed. However, the hammer is not forced downwards but it is allowed to fall under the influence of gravitation alone. The velocity, and consequently the energy, of the impact is thus a constant quantity.

In performing a test, the specimen, if of suitable size and shape, may be placed in a clamp furnished with the instrument, and the whole put in position upon the base of the scleroscope. It is important that the surface be smooth, clean and horizontal. If necessary, the locality when the test is to be made may be polished by an emery wheel or the like. If the object is small but irregular underneath, it may be imbedded in a preparation of tar and asphaltum. This substance permits of adaptation to the irregularities and at the same time opposes a firm resistance to an instantaneous blow. If the object is large the instrument may be arranged to suit the



HUGHES & KRYLOFF APPARATUS ARRANGED FOR TESTING RAILS

THE SCLEROSCOPE AND ITS ATTACHMENTS

circumstances by means of the swinging bracket. In fact, the scleroscope proper may be entirely disengaged from all support and operated while held in the hands, the plumb rod enabling a vertical position to be correctly assumed. This is an important feature of its adaptability to any and all conditions.

There are two vital parts of the instrument—the tube and the hammer. Great difficulty has been experienced in getting tubes accurate in bore and straight. No commercial method of grinding or otherwise producing a straight and uniform hole has been found. The tubes used are selected from a considerable quantity. This, of course, entails great waste. The hammer, however, presented the great—and for a time, insuperable—difficulty. To strike the tremendous blow required necessitated that the hammer have a very small area of impact. The diamond and other jewels were experimented with, but all failed. Prolonged experiments were made with steel. In this investigation the scleroscope, though itself not yet perfected, assisted. Finally, a method of treatment was discovered which enables the makers to produce a fine-pointed hammer capable of withstanding the severe shock. Such a hammer is cap-

REAR VIEW OF THE SCLEROSCOPE

able of being used upon the hardest of hardened steels for hundreds of tests, but ultimately it will need repointing.

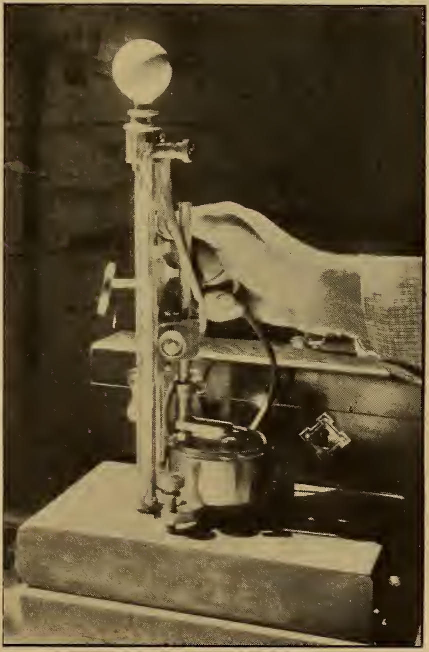
In making a table of the comparative hardness of the various metals, it is, of course, necessary that the hammer be identical throughout. However, in the case of the softer metals, if it is desired to distinguish small differences, a blunter hammer is used.

In reference to the development of the hammer, it may be added that the steel ball was experimented with, but led to no fruitful results, as it was too blunt.

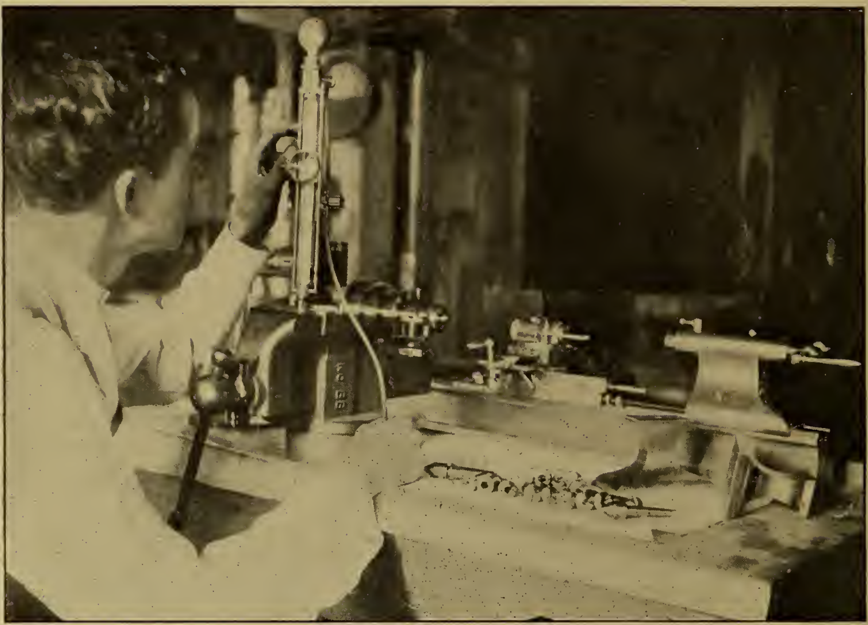
A table of hardness of metals disclosed great variations, ranging from 2 for lead to 110 for the hardest of steels. Porcelain shows 120 and glass 130. Babbit metal varies from 4 to 9 or 10, copper has a hardness 6, zinc 8, soft brass 12. Wrought iron is 18, while gray castings range about 39—more than double. Mild steel (steam rails—about ½ per cent. carbon) ranges from 26 to 30. Tool steel of 1 per cent. carbon, if well annealed, may be as low as 31. The same steel in the form of drill-rod rises to 35 and 40. Hardened tool steel of 1 per cent. carbon leaps to 90 and higher, reaching even to 110, which latter appears to be somewhere near the high-water mark for the metals. High-speed tool steel, hardened, is somewhat lower, with 80 to 105.

The effect of compression in developing a higher degree of hardness is quite marked in certain metals. Thus lead increases from 2 to 3, copper rises from 6, even to 14 and 20. This is a remarkable change and may contain within itself some fact of high importance in metallurgy.

Babbitt metal discloses a rather anomalous phenomenon. The effect upon the babbit sleeves in a bearing is one of compression. We should expect therefore that this would result



TESTING THE HARDNESS OF A LARGE PLATE WITH THE SCLEROSCOPE



TESTING THE HARDNESS OF MACHINE PARTS. IF THE THREE SEGMENTS OF THE CHUCK ARE NOT UNIFORMLY HARD THEY WILL WEAR UNEQUALLY

in an increased hardness. This is true, but only for certain varieties of babbit. The softer mixtures having a scleroscope hardness around 4 do indeed harden, but the hard varieties (9 and 10) become soft. This is really a matter of importance, as it points out the proper course to pursue, and it likewise emphasizes the usefulness of such an instrument.*

The instrument is being used by numbers of the leading manufacturers and can scarcely be styled an experiment. The Firth-Sterling Crucible Steel Co., of McKeesport, Pa., have made an exhaustive series of tests with the steel-ball method and have compared their results with those disclosed by the scleroscope for the very same specimens of steel. The two series are almost parallel. Scleroscopes are also in use by such firms as the Brown & Sharpe Manufacturing Co., the General Electric Co., the Westinghouse Co., the Packard Automobile Co., etc.

*This device is the invention of Mr. A. F. Shore (Shore Instrument & Manufacturing Co., 226 W. 24th St., New York City), who was materially assisted by Dr. Paul Herould, a French metallurgist.

What promises to be a very important development is the law laid down as to the relation that must subsist between the cutting tool and the work. It has been found that if the scleroscope hardness number of a metal is double that of another, the one will cut the other. But this ratio of 2:1 is not sufficient guaranty of a commercial life to the tool. To secure that the principle asserts that the tool must be 3 to 4 times as hard. Thus, if the work is of steel disclosing a hardness of 31 or 32 it will require a tool having a hardness of, say, 98 or 100. A tool showing but 90 is scarcely hard enough to make it true economy to employ workman and machine with it. Of course, there is some room for variation here. The shape of the cutting edge, the amount of support the edge gets from the surrounding parts of the tool, the depth of the cut, peripheral speed—all these are factors and influence the question as to the proper relative hardness. But these factors may be standardized, whereupon a ratio suitable to them should be sought. For the variations arising

TESTING THE HARDNESS OF A FILE WITH THE SCLEROSCOPE

in consequence of differences in practice, the standard ratio would be then used as the basis of calculation. This is a very promising line of application of the hardness tests. For general lines of work the rule may be adopted that the cutting tool should be three to four times as hard as the metal to be cut.

A matter of great value in the assembling of machines is the predetermination as to which of two contacting parts will prove the softer. The difference may not be great. But if this difference can be ascertained beforehand, then the pieces may be so chosen from the stocks of duplicate parts that the more expensive one shall be in contact with a softer, cheaper one.

We do not know that the maker of the celebrated one-horse shay had a hardness tester. At any rate, he so constructed the vehicle that the wear proceeded equally. This is the ideal upon which the manufacturer of machinery should have his eye. And the way to attain the goal is to determine the comparative wear of the different parts, and then construct each of just that material which possesses the precise degree of hardness. This is the direction in which the metal world is moving.

STANDARDIZING SCLEROSCOPES

We have now considered three modern methods of testing for hardness. They are widely different in respect to their basic principles. The difficulty of properly estimating these is due, in part, to our ignorance of just what we mean by hardness. It is not only possible, but quite probable, that we often confuse tenacity in part with hardness. Thus, when we find that a certain alloy steel resists the attack of the file equally well with a sample of pure carbon steel, we are apt to jump at once to the conclusion that both are equally hard. But when we reflect that tenacity may be assisting the alloy steel in making its resistance to the slow-moving file we are apt to see ground for hesitation. Indeed, the question of time would appear to be a very important factor. Consider the tar-asphaltum used by the scleroscope people in providing a rigid support for certain irregular specimens. This substance is very plastic if *time* be granted. On the other hand, it seems to meet our ideas of hardness if time is not an appreciable factor. Those rivers of ice in the Alps and far-northern regions known as glaciers adapt themselves to the inequalities of the bed. Their movement is incredibly slow, but nevertheless real. Yet we regard ice as hard. So this question of time seems to enter pretty decisively. The Brinell process seems to be defective here. For this method is characterized by its deliberation. Still,

as will be pointed out, there is a compensating action at work that may, to some extent at least, nullify this defect.

The scleroscope device is based on the practical elimination of the time factor. Further, it would seem to imitate pretty closely the tool cutting its work. For the hammer strikes a blow effecting actual and approximately instantaneous displacement of metal. It, like the cutting tool, acts with a force exceeding the elastic limit and acts quickly. In the Brinell process, on the other hand, the tool is only partially imitated. True, an action effecting a permanent deformation takes place. But this is accomplished so slowly that it would seem that tenacity comes in to obliterate the effects of hardness. The indentation is not so deep—not because hardness alone resisted, but because it was assisted by tenacity. But there is a corrective tendency. What is measured is not the amount of penetration but the depth of the *permanent* indentation, which is, of course, less. Of course, there are occasions on which we desire to measure resistance to displacement effected by any qualities you please and where time is permitted to enter. But this is scarcely hardness.

The electric method depends on principles entirely distinct. It is a process which seems to be characterized by great sensitiveness. And if its fundamental assumptions prove well founded, it promises to find a place for itself.

# THE GAS ENGINE AS APPLIED TO THE OPERATION OF TEXTILE MILLS

By A. Vennell Coster, M. Inst. M. E.

THE advent of the gas engine as a commercial prime mover is, at the present time, affecting in an increasing manner the commerce and trade, not only of Great Britain, but of the whole civilized world. It has undoubtedly attained its present prosperous position much more rapidly than did its rival, steam power. The steam engine required about one hundred years of its development; the gas engine has taken less than twenty-five years; and when we consider the number of firms who have taken up its manufacture, and the lack of experience in many cases, it must not be wondered that difficulties and obstacles have been encountered during that brief period.

The total output of some large firms may be of interest to show what strides are now being made. Messrs. Crossley Bros. are now building engines of more than 800 brake horse-power units in two cylinders, or 1,600 in four cylinders, driven by producer gas. They have supplied more than 56,000 gas enines of a total indicated horse-power of about 2,000,000, and gas plants of 150,000 horse-power during the last six years. These are driven by all sorts of fuels; coal of all grades and coal-dust, tar, coke, lignite, wood, wood-shavings, peat, sheep-skins and waste fats and grease, olives and orange-skins and refuse generally, and last, but not least, blast furnace gas, of which millions upon millions of cubic feet are annually wasted in Great Britain alone. Our German neighbors are far in advance of us in utilizing this gas for the purpose of driving gas engines, which can not only deal with fans and blowers necessary for supplying air to the furnaces, but also for driving electrical generators which supply light for the buildings and factories connected with the furnaces, and also supply light and power in the form of electricity to neighbouring townships. This places them in a much better position for exporting their raw or manufactured iron, and thus competing with the more sluggish and conservative Britisher. It is not so much tariff reform that is required, but more up-to-date methods and enterprise on the part of British manufacturers in using these waste products of combustion.

In Germany there are many large firms building gas engines, the Otto-Deutz and the Nürnberg firms being the largest. The latter are now building gas engines of 4,500 brake horse-power maximum, and have constructed double-acting engines totaling more than 300,000 brake horse-power. Most of these engines are for use with blast-furnace or coke-oven gas. Also the great firm of John Cockerill in Belgium, a firm that was founded early in the last century by an Englishman of that name. This firm and their English manufacturers, Messrs. Richardsons, Westgarth & Co., build engines from 250 to 5,000 indicated horse-power and have more than 10,000 horse-power now at work in England.

One of the great tests of reliability is the non-stop continuous run test. Messrs. Crossley Bros. undertake to supply gas engines regularly for a non-stop run, night and day, from early on Monday morning to late on Saturday night. At Messrs. Brunner, Mond & Co.'s works at

Northwich, one of these engines, of about 120 brake horse-power, operated a dynamo which never stopped running for a single moment, night and day, for more than seven months; and many large gas engines run from one to three months in a similar manner. Such long periods of running are, of course, not desirable. A full week should be ample to meet the demands of almost every type of manufacture, but there are exceptions, which the gas engine can meet. It is a decided advantage to let the engine have a rest, to have the valves overhauled, and the lubricating arrangements and fittings adjusted, so as to keep everything in the pink of condition. But these records are given to show that the gas engine, in the hands of careful and intelligent men, is one of the most reliable of servants.

As regards gas plants, whether of the suction or pressure type, these also are designed to undertake the supply of gas for long periods without rest and to maintain their economy and efficiency under all circumstances. Messrs. Crossley have in their own works gas producers that have been in continuous work for the past eighteen months. There is one case of a producer, making gas for heating purposes, that has never been stopped or been cleaned for five years; and when it is remembered that in these producers the pressures are only slightly above or below atmospheric pressure, one can realize the enormous advantages they possess over the best steam-boiler plant, either for economy, upkeep or safety points of view.

The recent annual report issued by Mr. Michael Longridge, of the Engine and Boiler Insurance Company, also proves the remarkable advance in reliability which the gas engine has made. In his analysis of breakdowns, the gas engine in his last report shows to better advantage than the steam engine in less liability to break-down and accident, so that without exaggeration we can say that in respect of reliability the gas engine is equal to the steam engine.

One of the great advantages of the gas engine over the steam engine appears in the great reduction in stand-by losses, these being quite seventy-five per cent. less than in the steam engine. This is of great importance in many businesses where the power is required intermittently.

An important example of this feature of the gas engine appears in connection with the high-service water supply system for fire protection, already installed in several cities in the United States, and described in this magazine in the issue for March, 1908.

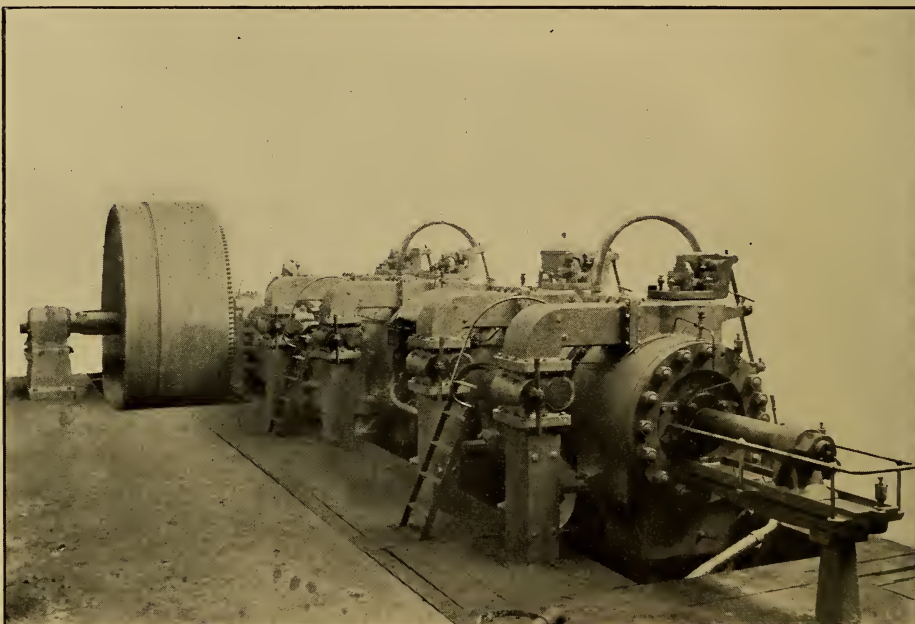
Besides the installations in Philadelphia, New York, Brooklyn and elsewhere, we may note a plant of this system just completed for the city of Winnipeg, Canada, this consisting of six gas-engine units—four of 520 horse-power and two of 250 horse-power each—delivering water into the city mains at a pressure of 300 pounds per square inch. The engines and producers for this plant were furnished by Messrs. Crossley Bros., and the pumps by Messrs. Clenfield & Kennedy, of Kilmarnock. Another instance in which intermittent service is important is found in the operation of electric generators for lighthouse service and for the operation of fog horns. The operation of pumps for removing water from drydocks is another example for which gas power has been successfully adopted, there being four units, aggregating 2,000 horse-power, installed at the Mersey docks for this purpose, the engines driving Tangye centrifugal pumps.

The modern manufacturer is a very different person from the manufacturer of fifty years ago. As a rule he is practically a trained engineer and knows the type of engine that will suit his purpose best, and is able to criticise its design, so that there is less likelihood of mistakes being made when installing new power plants. At the same time, there is still a great amount of preju-

dice against the use of gas power, which appears to lack foundation when the important advantages of heat efficiency, greater safety and low running costs are considered. Many of the arguments offered against the use of the gas engine may in the near future be put alongside the arguments of that quaint old Lancashire mill owner, when he determined to discard part of a more economical steam-engine plant which had been installed in his mill. An old non-condensing engine had been taken out and a new compound engine with condenser had taken its place, but not many weeks had elapsed after the plant had been taken over when he determined to remove the condenser, with its air and circulating pumps and return feed-water pumps to the boilers. On his next visit, the engine-builder found, to his amazement, that the boilers were being fed directly from a neighbouring brook. The reason for this re-arrangement was the old mill-owner's theory "that water once 'biled' is no good for making steam again, no more than it is for making tea."

The special application of gas power to which attention may now be directed is that of the operation of the machinery of textile manufactories, and particularly to the driving of cotton mills.

There is no doubt that the cotton mills of Lancashire are among the wonders of the manufacturing world, depending, as they do, upon imported raw material, which is subsequently exported in a wonderful variety of finished goods. Competition with Great Britain for the markets of the world is much more closely contested than in the years gone by, and it behooves British manufacturers to do all that is possible to reduce their working expenses. One of the greatest losses is undoubtedly incurred in changing the heat value of the coal into power output from the machinery. The thermal-efficiency problem is one of the greatest at the present moment that confronts the chemist and the engineer. Neither steam nor gas engineers have much



CROSSLEY DOUBLE-CYLINDER, DOUBLE-ACTING GAS ENGINE AS INSTALLED FOR COTTON-MILL SERVICE

to boast of as yet in this respect, when we consider the economy that is now obtained; even in up-to-date steam and gas engines of 1,000 to 2,000 horse-power for cotton-mill driving. Of the total heat available in the coal, approximately 13 per cent. only is turned into actual work in the steam reciprocating engine; 15 per cent. only with the steam-turbine engine, and about 25 per cent. with the gas engine. High-speed steam turbines are usually coupled to an electrical installation. From these figures it can be seen, that although 75 per cent. of the heat in the coal is lost with the gas producer and the gas engine, still the gas engine has approximately a thermal efficiency about 100 per cent. better than the steam engine. This is how things stand at the present moment, a matter which should demand the closest investigation of every power user.

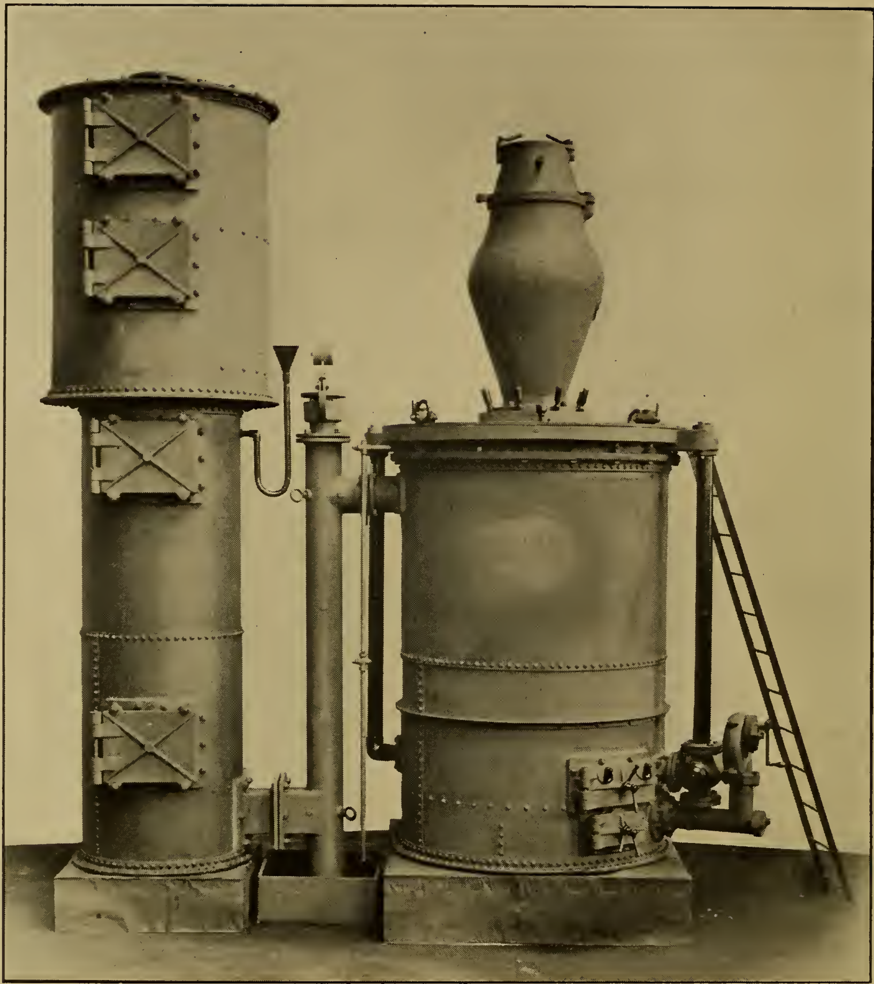
It would be presumption to say that the carefully-devised systems for power production and manufacture, which have been in vogue in Lancashire for so many years past, have been not of the best for cheap production or economy. The perfection to which the steam-engine installation has now been brought for this special service is well known, and now, with the advent of superheated steam in conjunction with improved reciprocating and turbine engines, extraordinary thermal efficiencies are being reached in large installations, installations which have proved themselves both for reliability as well as for elasticity with overloads. We must consider, however, the advent of another power, which has during the last twenty-five years made wonderful progress. The gas engine will take its place alongside of the most up-to-date steam engine and be able to fulfil the same duty, and have an equal reliability, combined with a distinctly improved thermal efficiency, together with enormous reduction in stand-by losses. The gas engine has already been installed in several cotton mills, and is doing its work satisfactorily. For this service, suction plants up to 1,000 horse-power can be furnished, using not only anthracite or coke for fuel, but also the cheaper qualities of non-caking bituminous coal.

It will be of interest to compare fuel consumption of a large steam reciprocating and turbine plant in Manchester, of from 6,000 to 7,000 kilowatt capacity, with those of an up-to-date suction gas-engine plant. The steam plant consists of Babcock & Wilcox water-tube boilers with mechanical stoking equipment and forced draught, supplying steam at over 200 pounds pressure to a 6,000 kilowatt Willans-Parsons turbo-generator, having a mechanical efficiency of about 93 per cent. The guaranteed consumption of fuel for the steam plant works out something as follows:

Coal consumption per indicated horse-power at full load .................... 1.11 lb.
Coal consumption per indicated horse-power at three-quarters load ............ 1.52 lb.
Coal consumption per indicated horse-power at one-half load ................ 1.6 lb.

These results agree well with the statements of prominent Continental steam-engine builders, who claim to be able to guarantee fuel consumptions as low as 1 pound per indicated horse-power, or about 1.1 pounds per brake horse-power.

These are very excellent figures, but much better results are guaranteed by competent builders for suction-gas plants. For instance, with large suction plants, a fuel consumption of 0.8 pound of coal per brake horse-power, or 0.68 pound per indicated horse-power, at full load is obtained, or 0.72 pound per indicated horse-power at three-quarter load and 0.85 pound at one-half load; the mechanical efficiency of the engine being taken at not less than 85 per cent. With such a plant the stand-by losses will not exceed 7½ per cent., and the consumption of



SUCTION GAS PRODUCER 500 HORSE-POWER. CROSSLEY BROS., LTD., MANCHESTER

water 1½ gallons per indicated horse-power per hour.

To give some idea of the small stand-by losses in a suction plant of about 500 horse-power, a hole 1 inch in diameter in the damper allows a sufficient quantity of air to pass through the furnace to keep it in condition while off duty, so that the plant can be started again the next morning without difficulty after blowing up for about ten to fifteen minutes.

Then it must be remembered that there is no elaborate machinery in connection with the producers, as is the case with the forced-draught automatic-stoked, water-tube boiler; that there are no boilers to burst, or steam pipes; but that, instead of these and many other parts subject to high temperatures and pressures, the gas-engine installation confines its high temperatures and pressures absolutely within the working cylinders of the engine. This is a very strong point in favour of the gas-engine installation.

The difficulties formerly experienced in starting large gas engines are now matters of the past. All that is required for starting pur-

DOUBLE-ACTING TANDEM GAS ENGINE. CROSSLEY BROS., LTD., MANCHESTER

poses is a small auxiliary gas engine and air compressor, together with a steel receiver for storing compressed air, arranged with automatic admission for the air to the engine cylinder.

So far as operative costs are concerned, the following figures may be of interest, these being taken from a recent report of a 1,250-horse-power bituminous gas plant, driving four Crossley gas engines, direct connected to electric generators of 200 kilowatts each, the costs being those per kilowatt-hour at full load:

| | Pence |
|---|---|
| Wages of attendant at switchboard | 0.083 |
| Coal, at 9s. 4d. per ton | 0.095 |
| Oil | 0.025 |
| Stores | 0.002 |
| Repairs | 0.010 |
| Total | 0.215 |

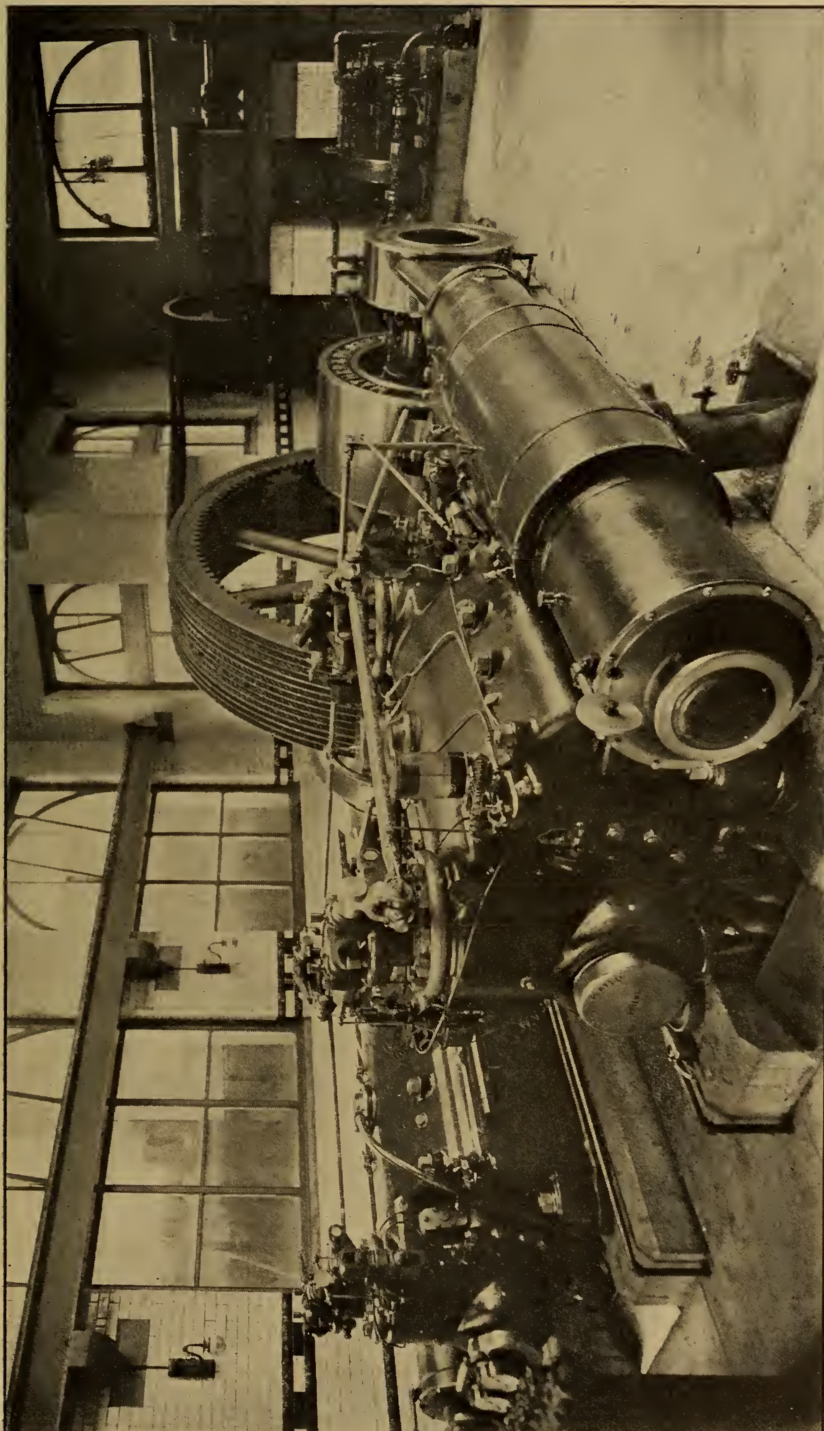
In reply to the question why the gas engine has a higher thermal efficiency than the steam engine, a plain answer can be given, namely, because in the gas engine the combustion takes place directly within the engine cylinder, where it does its work, and not, as in the steam engine, in a separate piece of apparatus, as the boiler, giving opportunity for many losses; also because it uses a medium which does not involve such conversion losses as steam.

As a matter of fact, engines have been made in which coal dust itself has been blown directly into the working cylinder; and, while theoretically correct, it will readily be understood that such a process cannot be satisfactory from a mechanical point of view, because of the injury to the working parts by reason of the grit and non-combustible residue.

The early steam-engine designers did what they could to diminish thermal losses, fixing the cylinder inside the crown of the boiler, and thus keeping it hot and reducing the loss by transmission of the steam. The gas engineer goes still farther, and extracts the gas from the coal in a producer, with a total thermal loss not exceeding 10 per cent., and then compresses and burns this gas with the correct proportion of air, directly in the cylinder. Although a large proportion of heat in the coal is thus actually delivered into the cylinder, a considerable proportion is carried away by the jacket water and exhaust, so that the bulk of it is not converted into work, and engineers are still making continual efforts to increase the efficiency. So far as proportions go, it appears that the best thermal efficiency is attained with a cylinder in which the piston chamber has a minimum of surface in proportion to its volume. The actual temperature of explosion exceeds that of molten cast iron, but, so far as known, that of the cylinder walls does not exceed 500 degrees Fahrenheit, being protected by the jacket water, while the temperature of the gases diminishes rapidly as the power stroke advances.

In many manufacturing industries heat is required for other purposes than for the generation of power, and this is particularly true of textile mills. When the gas engine is used, the hot exhaust can be passed through a boiler, assisted by the hot water from the cylinder jacket.

Roughly speaking, about 4,500 British thermal units per indicated horse-power per hour are available for this purpose, and with a steam-boiler efficiency of, say, 70 per cent., it is possible to increase the advantage of a gas-engine installation largely over a steam-engine installation, as this recovery of heat represents 0.25 pound of coal per indicated horse-power per hour, coal value taken at 12,400 British thermal units per pound. Such a steam boiler can be fitted with gas-producer connections direct from the gas producer, so that when the gas engine is standing the steam pressure can be maintained by the combustion of gas within its furnaces. This is becoming common practice in large in-



DOUBLE-CYLINDER KORTING GAS ENGINE OF 650 HORSE-POWER INSTALLED AT THE STALEY MILL BY MESSRS. MATHER & PLATT LTD., MANCHESTER

stallations demanding steam for auxiliary purposes, the exhaust temperature being approximately 1,300 degrees Fahrenheit. This utilization of the waste heat from the gas engine in a steam boiler is of especial importance in connection with the textile industries, since it provides the heat required in the various operations, also steam for humidifying, etc., and permits the gas-power plant to fulfil all the requirements of the service. It also means that, by the adoption of a gas-power installation, about 50 per cent. of the total heat in the fuel is converted into useful work, as against 17 to 20 per cent. in the best steam plant extant. It has been proved that the loss in a gas producer can be kept under 10 per cent., thus delivering 90 per cent. into the engine cylinder. In the engine about 25 per cent. of the heat is converted into useful work on the crank-shaft. Allowing 10 per cent. loss of heat in the exhaust pipes, and taking the efficiency of the steaming boiler at 70 per cent., another 25 per cent. of the heat in the fuel may be recovered as steam for any purpose required in the mills. A system which thus enables 50 per cent. of the thermal value of the coal to be recovered in power and heat is certainly worthy of the deepest interest.

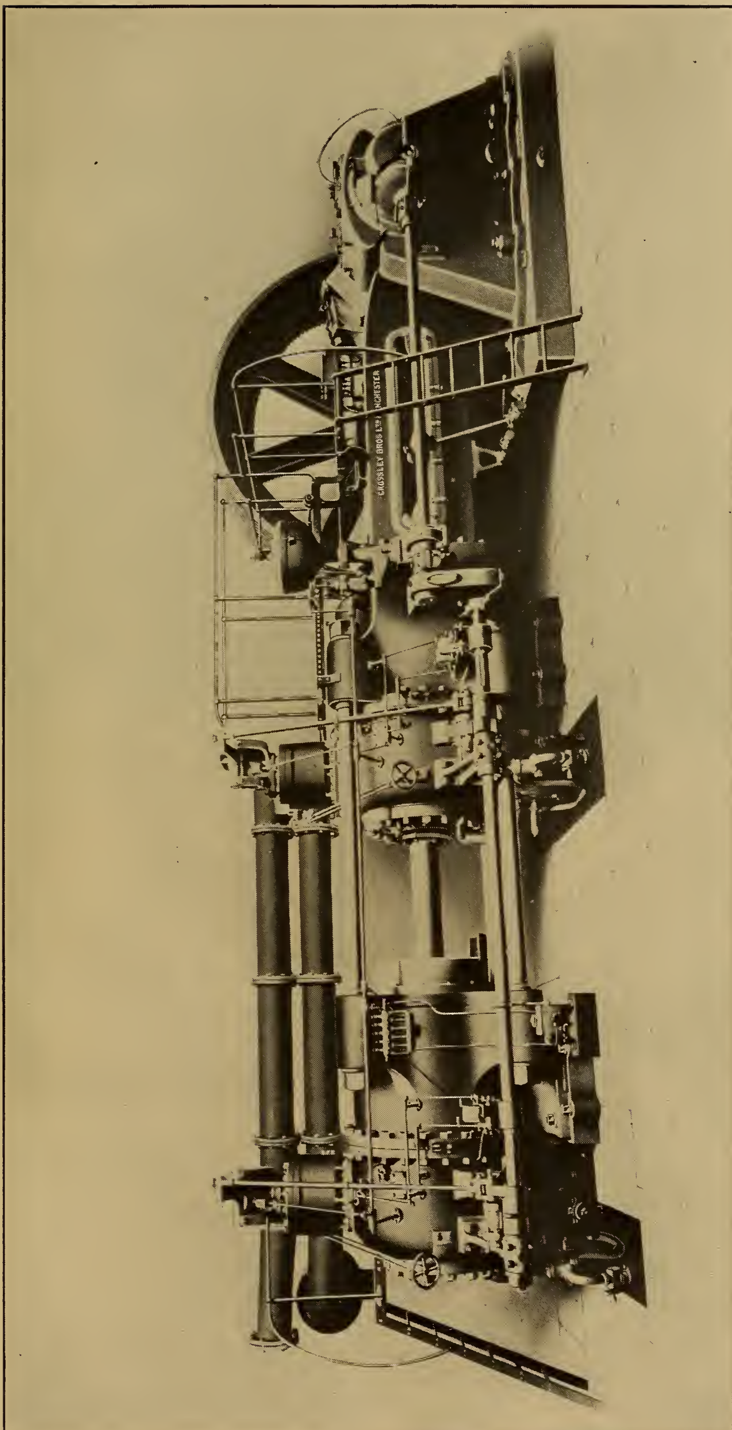
The explosive charge in the gas-engine cylinder is compressed usually to about 140-160 pounds per square inch, and for quiet and easy running, especially in horizontal engines, this compression should be maintained, whether at full or no load, by quality governing; that is, by varying the amount of gas admitted, but not the total volume of air and gas admitted.

Having stated as briefly as possible the reasons for the high thermal efficiency of the gas engine over the steam engine, the next question to be considered is whether the gas engine is suitable for cotton-mill driving. There can be, of course, no possible doubt as to the advantage of its higher thermal efficiency. This cannot be gainsaid, for it is one of the main reasons of its phenomenal growth up to the present time. As regards steadiness and smoothness of running, it will not be very difficult to prove that gas engines can now undertake as fine governing as the best-designed steam engine, for Messrs. Crossley Bros., the British Westinghouse Co., Ltd., Messrs. Mather & Platt, Ltd., and many Continental firms have already supplied large gas engines to drive cotton and spinning mills in various parts of the world.

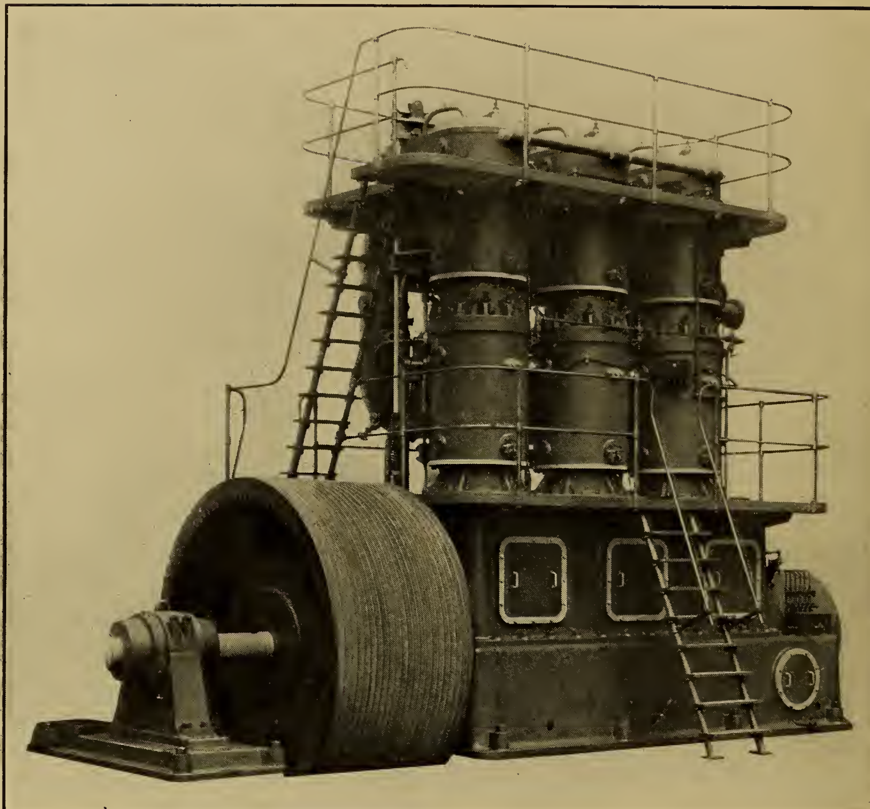
Quoting from the "Textile Manufacturer" of Nov. 15, 1907, we read:

"As the cost of power is such an important factor in the textile industry, it is very evident that any departure which will effect a saving in this direction merits careful consideration. Hence the rapid and pronounced development of large gas engines has attracted considerable attention from the textile power user. That such an economical source of motive power is not already utilized for the driving of textile mills is probably due to several causes, but we believe we are justified in asserting that the two chief considerations which have operated against the adoption of producer-gas engines for this service are the fears as to the reliability of the plant and the irregular turning which the average power user always associates with the gas engine. As far as the first objection is concerned, it is tolerably evident that it is one that experience may be trusted to obviate very effectually; indeed, the latest types of gas plants appear to be immune from liability to derangement, and we are assured that power users need have no fear as to the perfect reliability of the plant in general. As to the second objection, irregularity of running, we are able to give such evidence as will completely remove any misconception on this point."

One of the largest gas engines applied to the driving of mules and



HORIZONTAL TANDEM GAS ENGINE OF 700 HORSE-POWER, BUILT BY MESSRS. CROSSLEY BROS., MANCHESTER, FO THE SHIMODZUKE COTTON MILL, JAPAN



SIX-CYLINDER WESTINGHOUSE VERTICAL GAS ENGINE OF 750 HORSE-POWER, AT HOLLINS MILL, MARPLE

spinning machinery in Great Britain is that built by the British Westinghouse Company for the Hollins Mill Company, Marple. This is of the latest Westinghouse vertical tandem style, running at 200 revolutions per minute, and developing 750 brake horse-power, using producer gas as fuel. Running at a normal load of 700 horse-power, this engine uses 20 tons of coal per week, including banking producer over night and week end, the oil consumption being 5½ gallons per week. Tachograph diagrams taken from this engine show a much steadier and more even turning moment than with the displaced steam engine. This engine was tested by Dr. Nicolson, of the School of Technology, Manchester, the speed being reduced to 190 revolutions, to suit the requirements of the mill.

Under full load the thermal efficiency of the engine was 30.3 per cent., and at half load 25.9 per cent. The mechanical efficiency of the machine was 90 per cent., and the irregularity, as taken by Dr. Horne's tachograph, was equal to 1/400. This engine was operated with gas from a Mond plant in the builders' works, the load being supplied by a water brake of the Heenan and Froude type. An overload test was also carried out, showing that the engine was easily capable of developing 845 horse-power, or about 13 per cent. excess of rating.

It will be seen from the foregoing figures that this performance is, from a heat-unit standpoint, at least twice as good as any ordinary steam engine employed in cotton-mill driving. There is no doubt that the departure is being watched with a considerable

amount of interest by textile power users; and should the installation prove as satisfactory as others of the same type and size already in operation, there is every reason to anticipate that several cotton mills will discard their steam engines in favour of producer plant and gas engines, or as auxiliary power to steam engines that have been put on lower boiler pressure due to demands of the insurance companies.

Messrs. Crossley Bros. have supplied several gas engines for cotton-mill driving, a notable instance being a large two-cylinder horizontal tandem engine, the cylinders 38 inches diameter by 39 inches stroke, running at 105 revolutions and developing close on 700 brake horse-power. This has recently passed successfully through prolonged and exhaustive tests, and has been shipped to Japan, with a gas plant, to supply power to the Shimodzuke Cotton Mill. Its total cyclical and governing variation does not exceed 2 per cent. when changing from full load to no load. From its fly-wheel of 15 feet 6 inches in diameter twelve 2-inch diameter ropes connect up the engine to the mill shafting, supplied by Messrs. Yates & Thom.

A similar engine to this was tested by Dr. J. T. Nicholson, of the Manchester University, with the object of measuring the brake horse-power and gas consumption per brake horse-power, and also speed variation between full and light loads, by means of a new system of governing by a vacuum chamber. The gas used was made from bituminous slack coal in a Crossley producer plant, its calorific value being 156.5 British thermal units per cubic foot of gas. The brake horse-power per hour was obtained on a heat consumption of 8,128 British thermal units, or 31.32 per cent. thermal efficiency. The engine was found to vary in speed from 119.4 to 121.4 revolutions per minute when the horse-power was instantaneously dropped from about 600 brake horse-power to 50 brake horse-power. This represents a total variation of $1\frac{2}{3}$ per cent. of the mean speed.

An important example of gas power applied to textile work is seen in the double-cylinder Körting gas engine, built by Messrs. Mather & Platt for the Staley Mill. This engine develops about 650 horse-power, and is capable of 25 per cent. overload, as was shown upon one occasion when an air-pump failure compelled the stoppage of a steam engine for a week, during which time the gas engine developed about 900 horse-power, until repairs were completed. Operations during a number of months, driving a ring spinning mill by rope transmission, have shown very satisfactory results, the continuous records of a Moscrop recorder giving speed variations of only about one-half per cent., which is superior to the steam engines in the same mill. The load on this engine has varied from 25,000 to 41,000 spindles, and the fuel consumption of Lancashire coal is 0.9 pound per indicated horse-power per hour.

It may thus be safely affirmed that the gas engine of to-day is fully capable of undertaking the onerous work of driving all types of cotton and spinning mills. Manufacturers are prepared to guarantee the development of an indicated horse-power for less than one pound of slack or bituminous coal, of 12,400 British thermal units per pound. Very few of the latest and best-designed steam engines, using superheated steam and economizers, get down to $1\frac{1}{2}$ pounds per indicated horse-power in cotton-mill driving, and 2 pounds is a more usual figure. The gas engine offers a most immediate means of reducing the waste of fuel in power generation, and its entrance into the great field of textile manufacturing means an increase in the development and enrichment of the whole world.

# FLOOD-RESISTING BRIDGE CONSTRUCTION IN THE WESTERN UNITED STATES

By H. A. Crafts

Torrential streams present numerous difficulties in their handling, both as to the maintenance of banks and in respect of the design and erection of the bridges by which they are crossed. In the western part of the United States there are many streams which are nearly dry during a portion of the year, and yet subjected to sudden and destructive freshets at other times. In many cases the conditions were imperfectly understood by the earlier bridge builders, and in consequence there occurred serious losses by reason of washouts and bridge failures. The present article gives a brief account of the manner in which a bridge thus destroyed has been replaced, and the experience may be of service in similar locations in other parts of the world.—The Editor.

DURING the prevalence of some very heavy freshets in the spring of 1907 every bridge on the Feather River, California, with one exception, was carried out, and the number of wrecked bridges on the river was between eight and ten.

The Feather River, as may be imagined, is a torrential stream, and, moreover, one that is subject to very rapid and abnormal rises.

At Oroville, an important town on the stream, the rise at the time mentioned was 35 feet. The county bridge at that point, and one of comparatively modern construction, was one of those destroyed, and the lower part of the town was flooded.

The bridge was a complete wreck, everything being carried out, including the steel and concrete piers supporting the structure.

The only bridge left standing on the Feather River was one that had but recently been completed for the Western Pacific Railroad Company. This was designed and constructed by the Pacific Construction Company, of San Francisco, and of which F. A. Koetitz is chief engineer. It was located twenty-four miles above Oroville.

When Butte county, of which Oroville is the seat, came to advertise for plans and bids for the construction of a bridge to replace that carried out by the floods of 1907, this company became a bidder in competition with others, and was successful in securing the contract.

Of course, the main problem to be solved in the construction of this new work was to secure a structure that would successfully resist the power of the heaviest freshet that would be likely to occur again on the river.

This involved two points—increased height of bridge above the river and increased strength of piers and abutments.

The old bridge had been a steel structure, with Cushing piers, composed of steel cylinders filled with concrete.

These piers had been completely swept away, even down to their rock foundations, and it was therefore evident that some stronger design must be applied to the new structure in order to give it a character of probable permanency.

It was therefore decided to build the new bridge 10 feet higher above low-water mark than the old one, and to support it upon solid reinforced concrete piers, and with as few of these as was consistent with good and sufficient span strength, thus presenting to a possible flood as little exposed surface as could be well imagined.

The old bridge had had an elevation of 35 feet above low-water mark; the new bridge was therefore designed to be 45 feet above low-water mark.

The superstructure was planned in three steel spans, one of 174 feet in length, and two of 215 feet in length each.

OROVILLE BRIDGE. TEMPORARY BENTS ON PIERS, AND ARRANGEMENT OF SUSPENSION CABLES AND TRUSSES

OROVILLE BRIDGE. TEMPORARY SUSPENSION TRUSSES IN POSITION, AND 174-FOOT PERMANENT SPAN ERECTED THEREON

OROVILLE BRIDGE. VIEW SHOWING ABUTMENTS AND PIERS AND ONE 215-FOOT SPAN ERECTED

Thus, only three piers became necessary, and these were started at low water and upon a solid natural rock foundation. These were 45 feet high, 40 feet long at the bottom and 30 feet long at the top; 11 feet wide at the bottom and 5 feet wide at the top, with straight batters all around, but with the upstream exposures chamfered to a feather edge in order to facilitate the cleavage of flood waters.

The location of the bridge being on the edge of the city of Oroville, that municipality joined with the county in the construction of the bridge, contributing a 54-foot span with a solid concrete abutment.

The contract price of that portion erected by the county was $86,000, and of the part built by the city of Oroville $6,500, making the total cost of the new bridge $91,500.

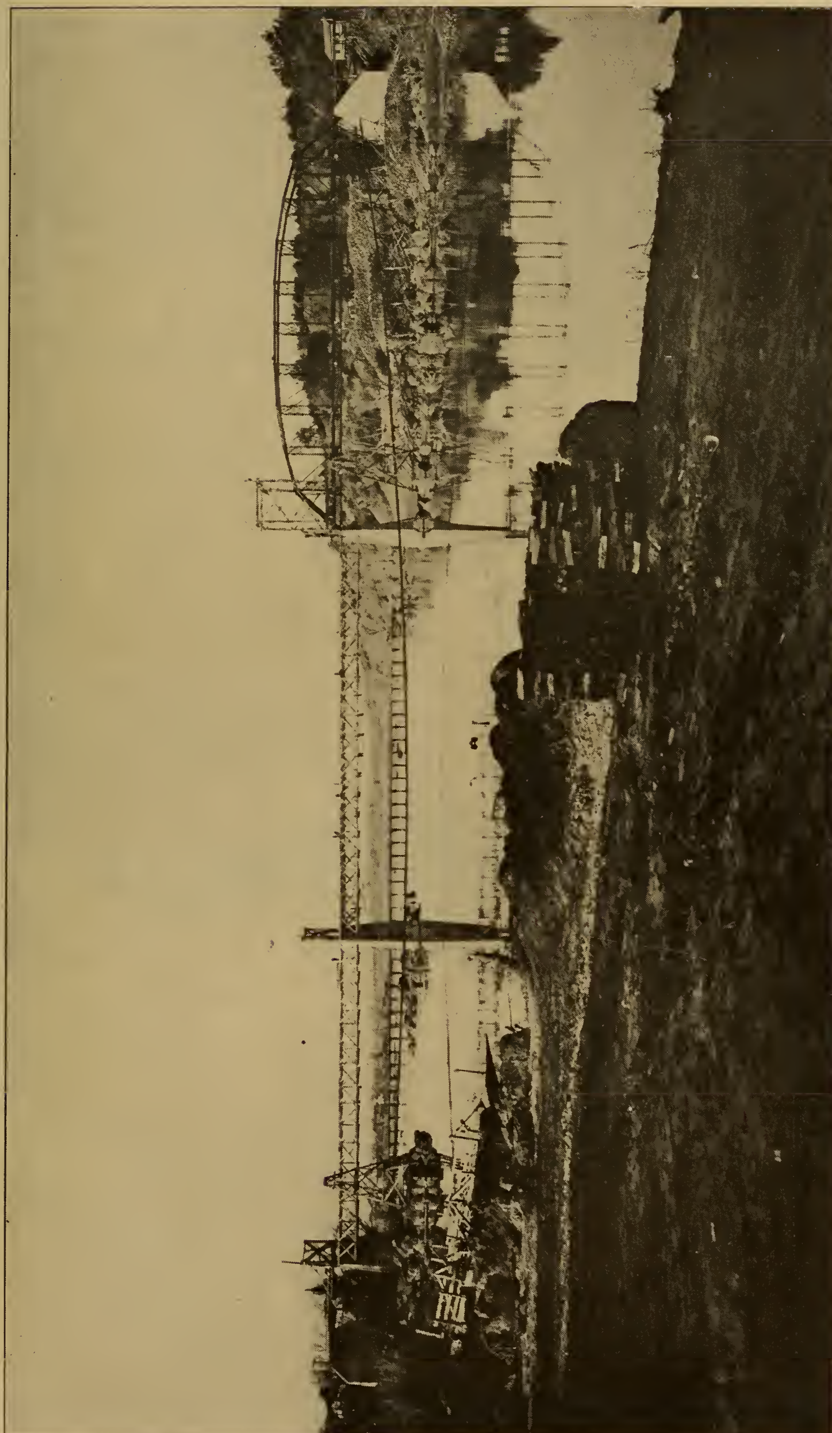
The contract for the bridge was let in June, but on account of the congestion of business both on the railroads and in the Eastern steel mills, the material for the superstructure was not delivered at Oroville until September, making it necessary to extend the time of construction into the winter months.

Of course, in the meantime the erection of the piers and other preliminaries had gone on, and these included the erection of false work across two of the main spans for the support during construction of the steel superstructure.

These two spans included the 174-foot span and the adjoining 215-foot span, and the suspension false-work was employed in order to avoid the dangers of floods during the winter months, when it was known the construction of the steel spans would have to be performed.

This suspension false-work was composed of the well-known Howe truss construction. Temporary wooden towers were erected on the concrete abutments on either side of the river, and over these were hung cables composed of three 1¼-inch cables.

These were securely anchored into the solid rock on either bank of the



ARRANGEMENT OF TEMPORARY SUSPENSION TRUSSES USED IN ERECTION OF FEATHER RIVER BRIDGE, OROVILLE CALIFORNIA

stream, and upon these were built the temporary wooden trusses, as shown in the illustrations.

The problem of controlling the loads during construction was solved by means of an additional counter cable carried overhead. The scheme worked very satisfactorily, and the spans were erected quickly and without accident of any kind.

This bridge has a buckle-plate floor, and the wearing surface is made of asphaltum concrete. On the down-stream side the bridge has a sidewalk for foot passengers; on the up-stream side the floor beams extend sufficiently to carry three large water pipes.

It will be watched with unusual interest because of the surrounding conditions. The Feather River is a mountain stream and subject, as has been said, to very rapid and heavy rises.

At Oroville it is especially turbulent during flood-tide, having a rocky bottom, high, steep banks and a bad bend at this particular point.

# THE RELATIVE ADVANTAGE OF HYDRAULIC AND ELECTRIC POWER FOR PORT AND DOCK WORK

**By Brysson Cunningham**

THE rivalry which exists between electricity and hydraulic pressure as motive agencies and sources of power becomes yearly more acute, and nowhere is the supremacy of either more closely and strenuously contested than in connection with the extensive array of appliances employed at ports and docks for the accommodation of shipping, and for the reception and despatch of merchandise. Dock-gates and bridges, capstans, sluices, cranes and jiggers constitute a vast domain of machinery and actuating gear wherein the rival forces strive unceasingly for the mastery.

It is useful at certain stages of such contests to review the situation, and to determine the extent to which experience has definitely proved the advantage to lie on one side or the other. This is not always nor generally an easy task. Statistics may be, as in the present instance, collected in considerable quantity and with great care and exactitude; but their efficient application to purposes of comparison is often marred, and even nullified, by the existence of exceptional conditions. It must even be avowed that generalities are not uncommonly based on insufficient or defective data, due, no doubt, in some part to a spirit of partisanship and commercial interest, but also to some inexplicable indifference, on the part of those not so actuated, to probe matters to the very bottom.

It is just about fifteen years now since electricity made its appearance on the scene as an active and serious competitor with hydraulic power. Prior to 1890, certainly, there was no such thing as an electric quay crane in existence. So far as the writer can ascertain, the first of these appliances appeared experimentally at the port of Havre about the year 1892, and was followed shortly afterwards by one or two others at the port of Rotterdam. The success attending the inauguration of this form of energy was indisputable, and from the year 1893 onwards the field of electrical appliances in dockwork was enlarged by great and frequent advances, to which there were no unfortunate setbacks, as in many other instances of industrial development. Before the close of the nineteenth century electricity had become fully recognized as a powerful antagonist to the older source of energy.

Hydraulic power had enjoyed a surprisingly long monopoly. For something like forty or forty-five years it had been in almost universal vogue, dating back to the year 1848, when Mr. Jesse Hartley introduced it into the Liverpool Dock Estate on the recommendation of Lord Armstrong, its pioneer and patron.

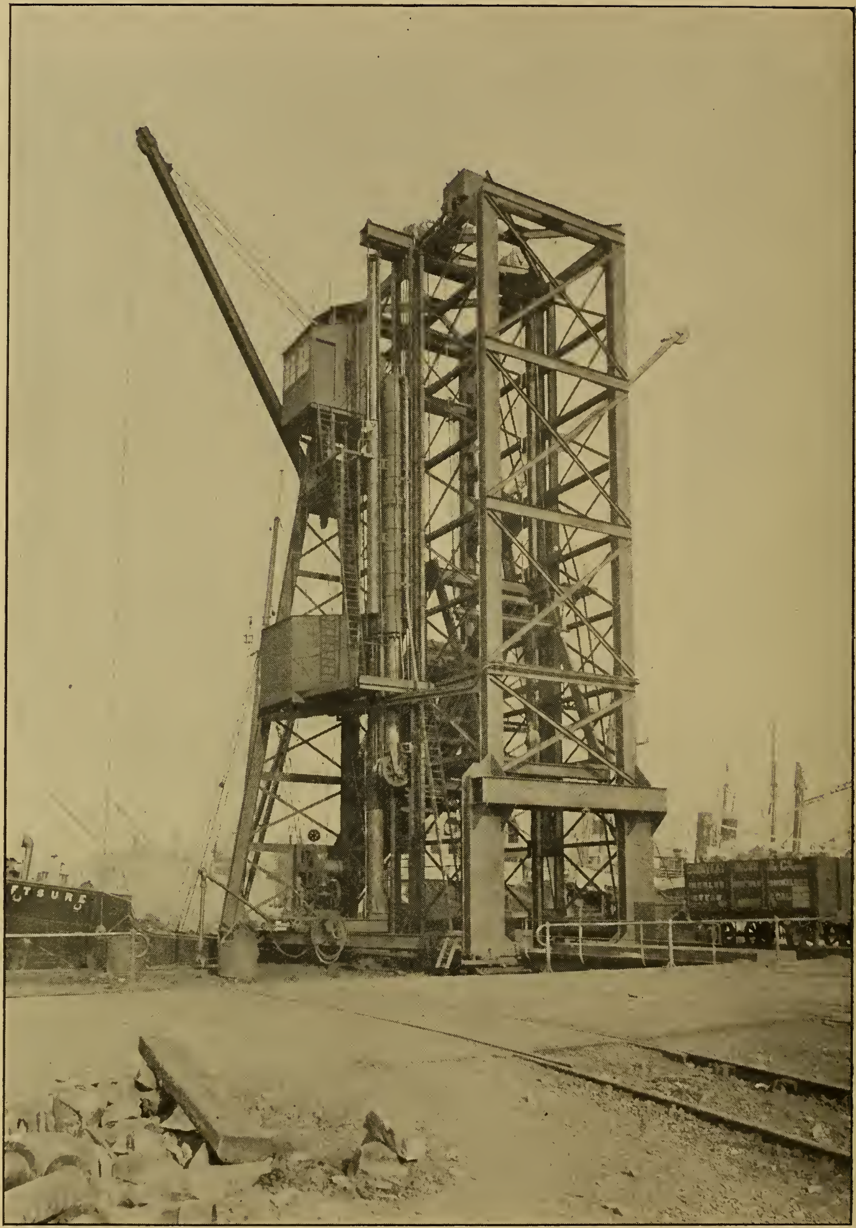
At the present time adherents of the older form of supply can point to the practically unimpaired maintenance of their position at London and Liverpool; while, on the other hand, electricity seems to be gradually working its way into the premier position at Hamburg and Rotterdam. At new or newly developed ports, principally in South America—as Rosario, Para and Rio Grande do Sul—electric plant alone has been installed. At the other and older

HYDRAULIC CRANE FOR CLYDE NAVIGATION TRUSTEES, GLASGOW. LOAD 2 OR 5 TONS, LIFT 75 FEET, RADIUS 41 FEET. GLENFIELD CO., LTD., KILMARNOCK

ports in Europe there is what may be called an indeterminate division of honours between the two systems in point of popularity.

Reverting to the main object of the present article, it is, perhaps, desirable, to begin with, to summarize briefly and in general terms certain prominent characteristics appertaining to each kind of power, considered without reference to any particular form of application. We will com-

PURFLEET 4½-TON MOVABLE CRANE, FITTED WITH PRIESTMAN GRAB BUCKET. SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., ELSWICK.



MOVABLE HYDRAULIC COAL TIP AT PENARTH DOCKS OF THE TAFF VALE CO. FIELDING & PLATT, LTD., GLOUCESTER.

mence, accordingly, with water under pressure.

Within practical limits, water is an inelastic and incompressible medium, and, therefore, any work done upon it is completely reproducible, with the exception of such slight losses as are inevitably due to leakage and friction. But this unalterability of volume has the disadvantage of rendering the fluid incapable of adapting itself as a motive agency

DOUBLE POWER, MOVABLE HYDRAULIC CRANE, AT DURBAN HARBOUR, NATAL. CAPACITY 3 TONS AT 50 FEET RADIUS. J. ABBOT & CO., LTD., GATESHEAD

to variable conditions of load. The motive effort is always the same, whatever resistance be opposed to it, and the same expenditure of energy is necessary whether the work done be considerable or insignificant. The power is invariable and rigidly uniform. Therefore, as a first principle it has to be recognized that hydraulic appliances are only economically used when applied to their maximum loads.

In contrast herewith must be set the fact that the expenditure of electrical energy is sensibly proportional to the work done. An electrical appliance can be utilized as economically for light as for heavy loads.

It should not be overlooked, however, that hydraulic machinery, as a class, is characterized by very high efficiency. In rams of the direct-acting type the efficiency is as much as 95 per cent. with ordinary hemp packing. Furthermore, there is great smoothness and regularity of move-

ment, absolute immunity from risk of fire, and a very high degree of safety. The appliances are capable of being manipulated with extreme precision, while they do not call for specially trained or skilled operators. Electrical appliances necessitate the inspection and attendance of qualified mechanics; in the absence of special enclosures for motors there is a certain risk of fire from short-circuiting; and, on the whole, it cannot be claimed that they act as safely, as smoothly and as precisely as does the hydraulic ram.

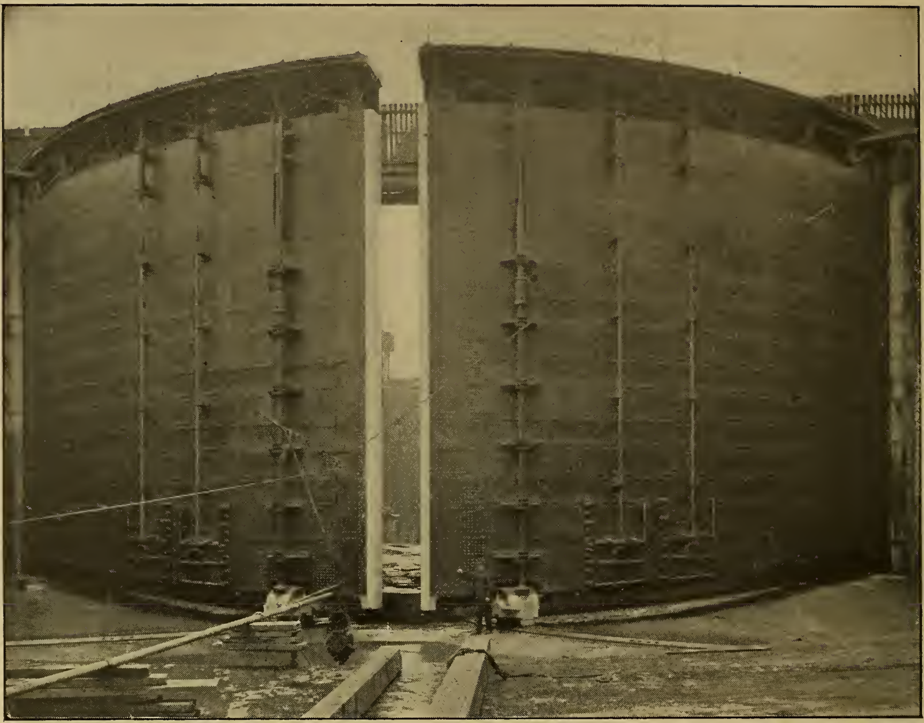
HYDRAULIC ROOF CRANE. CAPACITY 30 CWT. MERSEY DOCK AND HARBOUR BOARD. SIR W. G. ARMSTRONG, MITCHELL & CO., LTD., ELSWICK.

So much for the mechanics themselves. A word or two is also necessary in regard to the prime source of energy and the means of transmission.

Both electric and hydraulic energy owe their existence primarily to the steam or the gas engine, and one and the same agency is commonly utilized for effecting the pressure of water and for generating the electric current. In cases within the writer's knowledge a joint hydraulic and electric installation is served by the same set of steam boilers. It does not lie within our present scope to inquire whether gas or steam is preferable for the purpose. We leave this question, interesting though it be, for another occasion. Meantime, we just note the common origin of both forms of power and the approximate equality of their costs of production.

In regard to conveyance, there is not the same identification and economy of means, for while the electric current can be transmitted easily and conveniently by mains of extreme flexibility and compactness, hydraulic power necessitates a bulky and awkward canalization of cast-iron pipes,

ELECTRIC TRANSPORTER ROOF CRANE AT MERSEY DOCKS. CAPACITY 30 CWT. APPLEBYS, LTD., LONDON



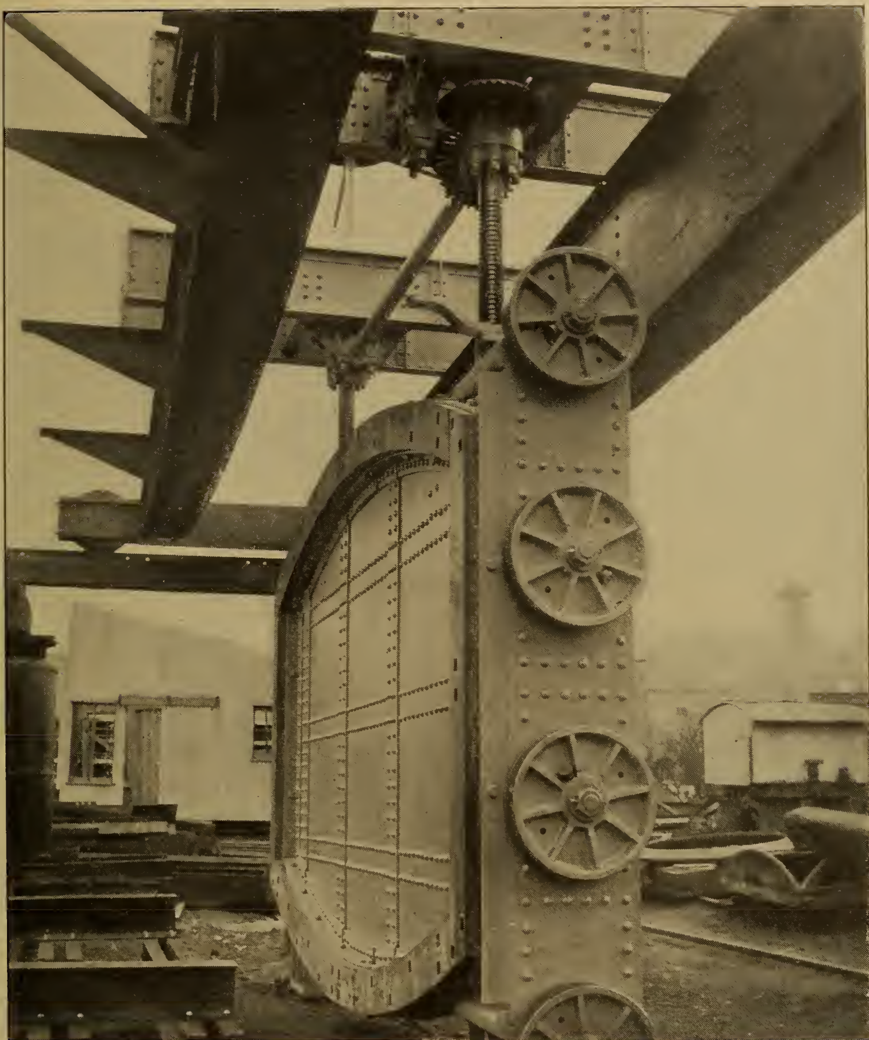
LOCK GATES FOR SURREY COMMERCIAL DOCKS; 80-FOOT GATES, SHOWING GATE-MECHANISM AND SLUICES

which have to be bedded some 2 feet in the ground to remove them beyond the reach of frost. The effect of low temperature, in fact, constitutes one of the more serious drawbacks to the use of hydraulic appliances, though the evil may be, and sometimes is, needlessly exaggerated. The ground in the neighbourhood of hydraulic machinery is often wet and sloppy from leakage, and this in the winter time in countries of Northern latitude leads to the formation of ice, which, of course, is a source of danger to anyone working at or passing along the quayside. Frost also causes congelation in the pipes and rams, with the likelihood of fracture; but these evils may be avoided by draining the pipes when out of use, and by use of gas jets and other means of artificial warmth.

So much, then, for general principles. We come now to a consideration of their application to special cases.

The working appliances of an ordinary port may be broadly divided into two classes, with an intermediate section formed by a few implements common to both. The first class includes all powerful machines for working heavy loads at speeds which are not required to be very great. Such are dock-gate machines, large sluice penstocks, massive swing bridges and coal elevators. The second class comprises light-running machinery, dealing with variable, small or moderate loads at a fairly rapid rate, such as quay cranes and warehouse jiggers, of powers ranging up to 10 tons, but lying generally between 10 and 30 hundredweight. The intermediate division may be said to embrace appliances difficult to allocate definitely to either of these, as capstans, winches and the lighter kind of movable bridges.

Characteristic of machines of the first class is their heaviness and uniformity of effort, necessitating gear



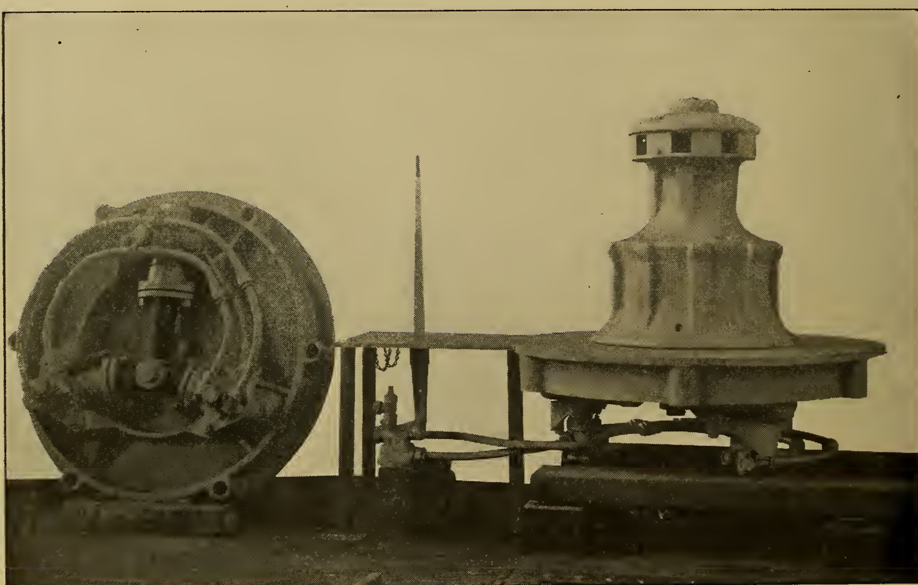
SLUICE GATE FOR KEYHAM DOCKS. STOTHERT & PITT, LTD., BATH

of considerable strength. Furthermore, they may be said to possess a special and trying environment. Dock gates have to be closed at times in the face of atmospheric conditions of an extremely adverse nature, when any failure of power would be a serious matter. And here lies the advantage of employing the agency of the hydraulic ram, which is exceedingly reliable and simple, without any complex or delicate mechanism to get out of order at a crucial moment. Moreover, gate and sluice machines lie almost universally below ground-level, and in such damp situations, unless special precautions are adopted, there are possiblities of leakage and breakdown in electric cables. It may, therefore, be laid down as a safe and definite conclusion that, in all exposed situations necessitating powerful machinery of fairly uniform capabilities, and, in fact, whenever loads are heavy, constant and slow-moving, hydraulic power can be utilized to advantage; and this despite many excellent perform-

ances standing to the credit of electric machines devised for these very purposes. The question is not simply one of economy. Considerations of reliability and control are of prior and, indeed, of paramount importance, and they should outweigh financial reasons, even if these operated adversely, which is not necessarily nor probably the case. Most engineers are satisfied that hydraulic machines are best adapted to this class of work.

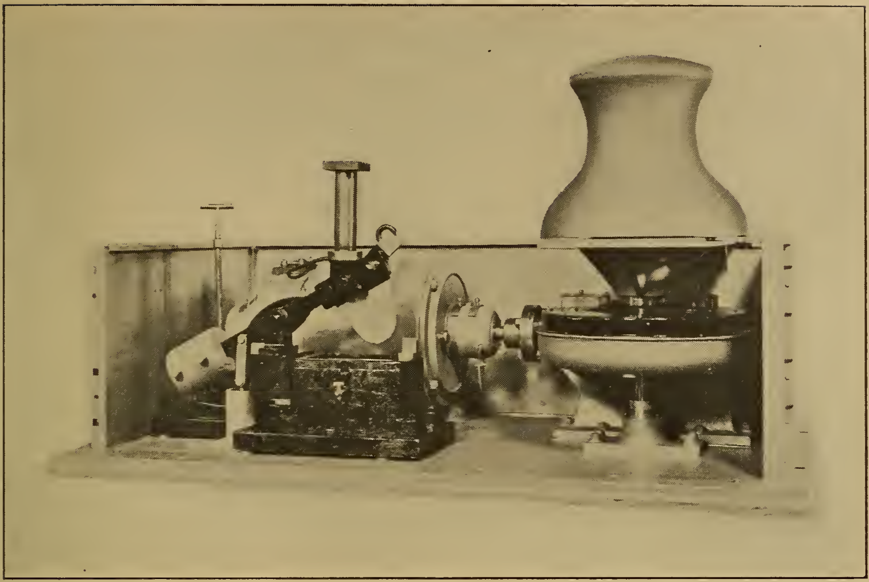
It is in connection with the second class of port machinery that the contest for supremacy is mainly fought, and conditions here are favourable to a more equal and exact comparison. It is relatively a simple matter to set an electric and a hydraulic crane to do work side by side under precisely similar circumstances of service and supply, such as could not possibly be the case with gate or sluice machinery. This has been done in a large number of cases, and we have the benefit of the results recorded.

But while the quantity of evidence thus collected is not inconsiderable, and while much of it is extremely valuable, it is not infrequently apparent that the whole circumstances have not been taken into consideration. Very often an imperfect comparison is based on actual power expenses without reference to maintenance, and more often still without reference to capital expenditure. It is, on the whole, easy to show a result in favour of electric cranes working under variable loads, if cost of power alone be taken into consideration, for the hydraulic ram is not, as has already been stated, an economical machine for variable loads.

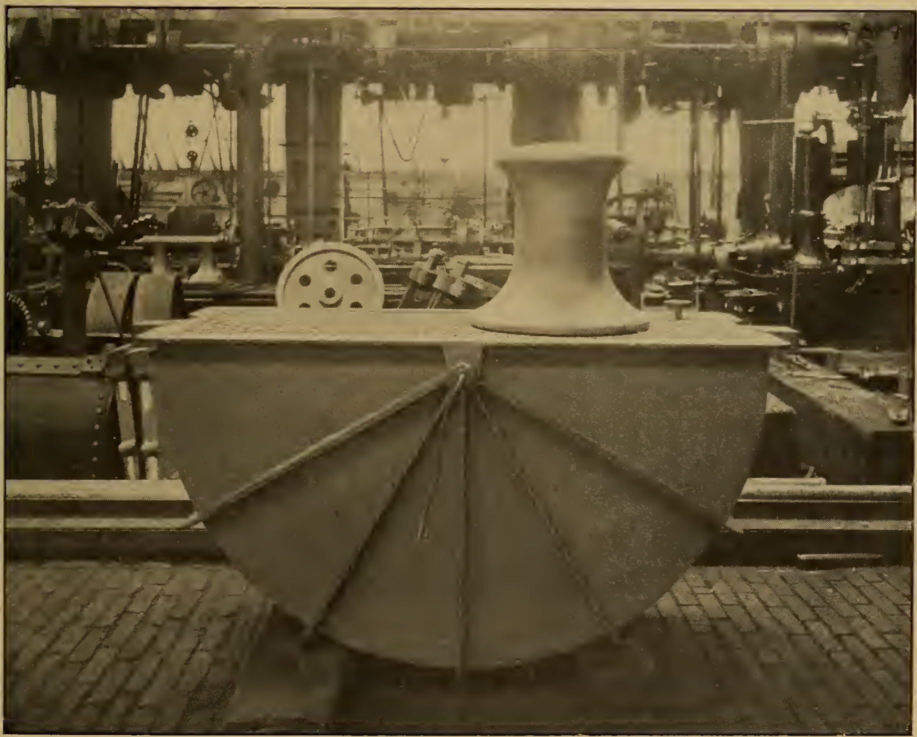


DIRECT-ACTING 5-TON HYDRAULIC CAPSTAN. SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., ELSWICK

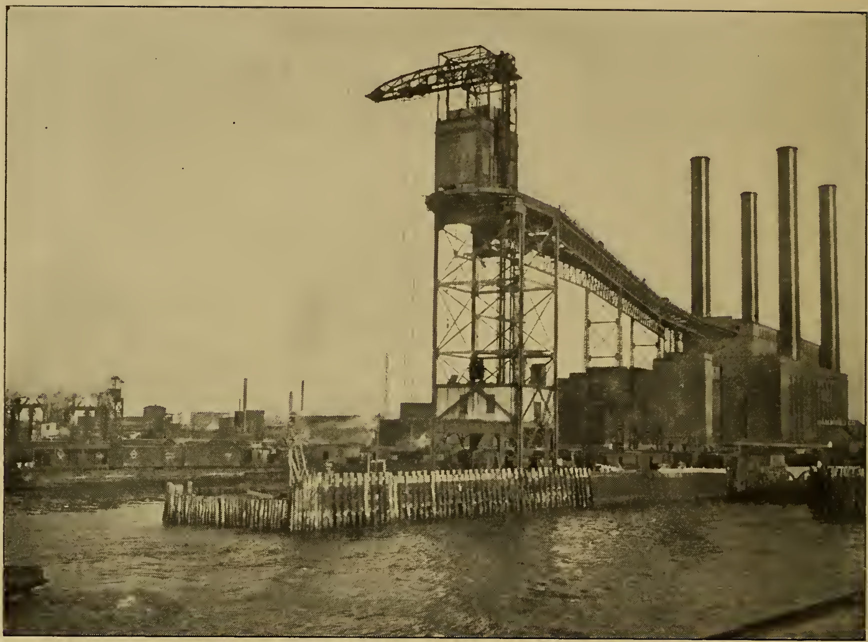
Quay cranes which lift up to 30 cwts. are mostly occupied in dealing with loads much below this limit, and this condition tells enormously in favour of the electric crane. Taking any ordinary class of goods, it is doubtful whether the usual load of a 30-cwt. quay crane would average more than a ton or 25 cwts. at the outside. In many cases it is as low as 12 or 15 cwts. It may be urged, of course, that this is one of the elements of the situation, and must be acquiesced in accordingly. Admitting this, it may also fairly be contended



ELECTRIC CAPSTAN, FITTED WITH 20-HORSE-POWER DIRECT-CURRENT MOTOR, WITH FOOT CONTROLLER.
E. SCOTT & MOUNTAIN, LTD., GATESHEAD-ON-TYNE



ELECTRIC CAPSTAN ON REVERSIBLE BASE. APPLEBYS, LTD., LONDON



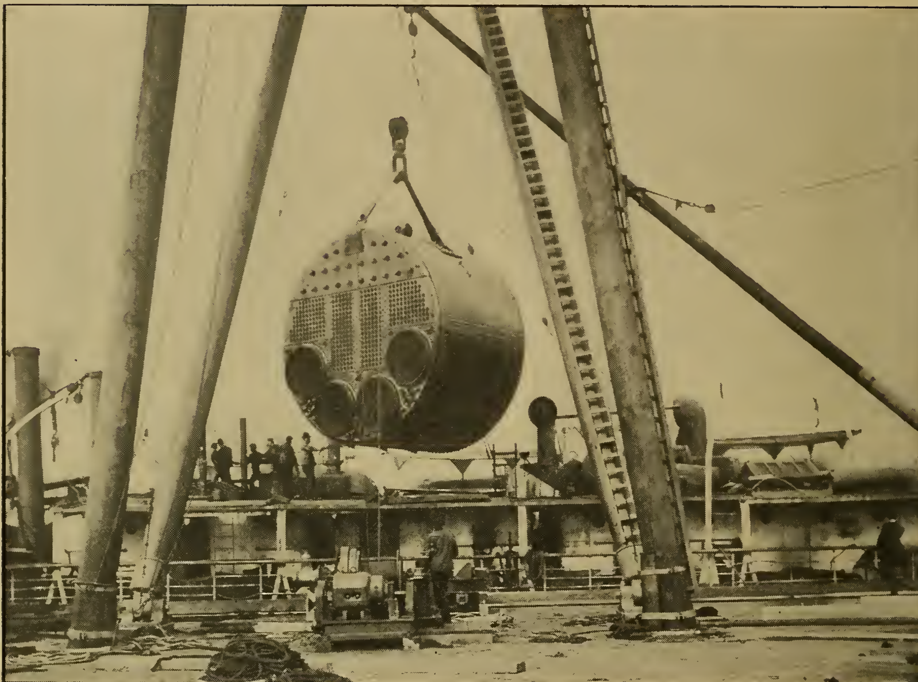
COAL-HANDLING TOWER OF LONG ISLAND CITY POWER HOUSE OF THE PENNSYLVANIA RAILROAD CO. HAYWARD CLAM-SHELL BUCKET. ROBINS CONVEYING BELT CO., NEW YORK

that other elements favourable to hydraulic power, such as prime cost, should not be omitted. A hydraulic crane costs considerably less than an electric crane, and, therefore, the current amount chargeable to interest and depreciation will be correspondingly smaller. As will be seen, this item plays an important part.

On a basis of personal experience, combined with an examination of data obtained from external sources, the writer has compiled what he believes to be a fair and typical statement of the current expenditure on the two classes of machine for a working hour consisting of thirty lifts, or cycles of operation, of the same character, and it is given below. It is not the actual record of any particular set of experiments, for the conditions under which these are made are rarely uniform for both cases, and certain corrections and eliminations are required to render the results suitable for purposes of direct comparison. It must be obvious that some of the constituent expenses will vary from time to time in greater or less degree, and especially in different localities. For the object in view, therefore, all that could be done was to give the items in some detail, with an estimate of their general value. In making any special application of the result, regard must be had to these fluctuating factors. Prinicpally they lie under the head of maintenance charges: lubrication, stores and repairs. Electric cranes cost very little for repair while new; but there is some amount of testimony to show that, after a few years, they are rather more expensive in this respect than are hydraulic cranes. The figures given for these variable items are the result of a fair range of investigation, and may be considered an equitable average.

A brief description of the cycle of operations is as follows: (a) Load lifted 35 feet, (b) slewed through 180 degrees, and (c) lowered 35 feet to the ground, with (d), (e) and (f) corresponding movements in the reverse direction, unloaded. The loads lifted ranged from 10 to 30 cwts.,

ELECTRIC CARGO CRANES AT GREENVILLE, N. J. C. W. HUNT CO., NEW YORK



LAMBERT HOISTING ENGINE CO.'S DRUM HOIST, WITH 40-HORSE-POWER WESTINGHOUSE ELECTRIC MOTOR, LIFTING 65-TON BOILER AT SEATTLE

but the expenditure of energy has been computed on an average lift of a ton. Decimals have been purposely avoided, in order to convey no misleading idea as to absolute exactitude of the figures.

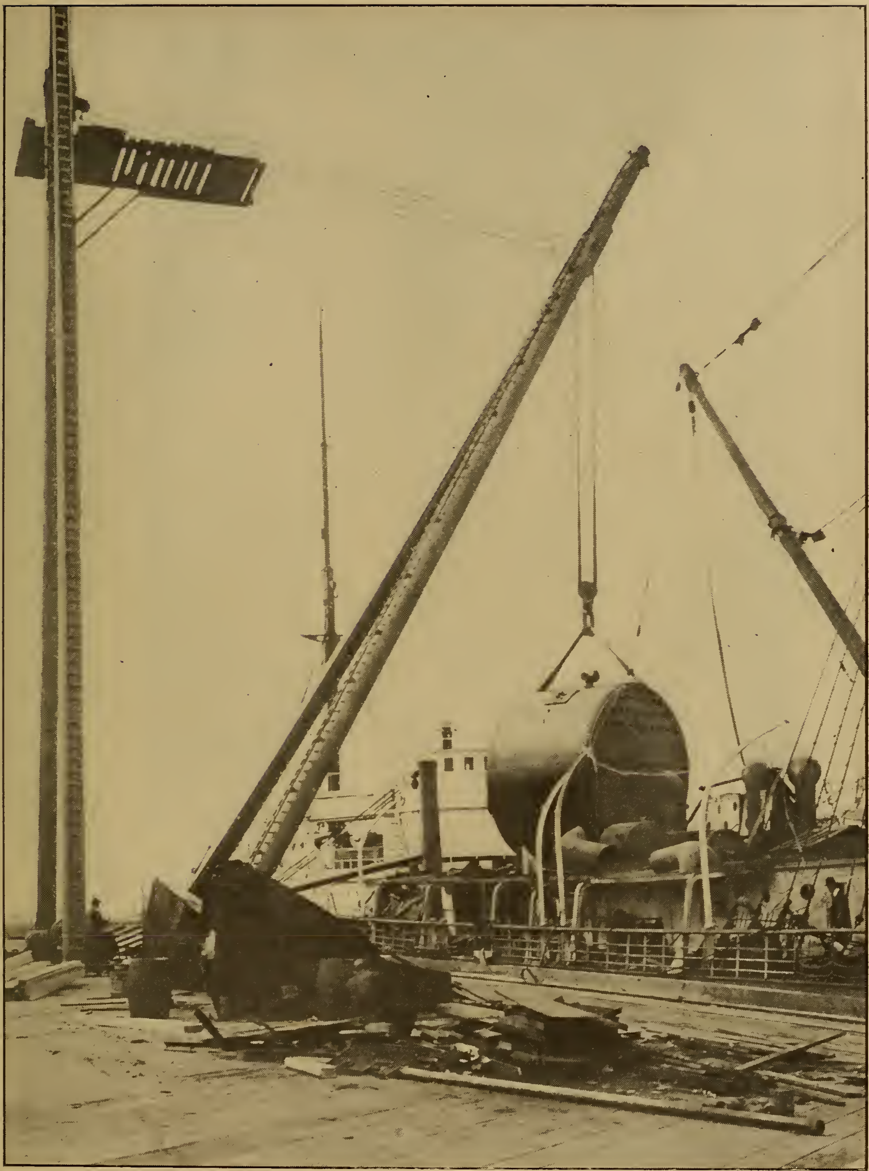
Comparison of the current costs of hydraulic and electric 30-cwt. quay cranes per working hour of thirty lifts:

COMPARATIVE COSTS OF ELECTRIC AND HYDRAULIC POWER

| | Cost per Working Hour, Hydraulic (Pence). | Electric (Pence). |
|---|---|---|
| Capital Expenditure: | | |
| Cost of hydraulic crane, say £550; allow for interest and depreciation 10 per cent per annum; assuming 2,000 working hours per annum | 6½ | |
| Cost of electric crane, £750; interest and depreciation as above | | 9 |
| Working Expenses: | | |
| Labor in lubricating and connecting up to mains | ¾ | ½ |
| Repairs | ¾ | ¾ |
| Oil and stores | ¼ | ¼ |
| Power Cost: | | |
| Hydraulic power at 750 pounds pressure for thirty lifts, 880 gallons at 6½*d* per 1,000 gallons | 5¾ | |
| Electric power at 1*d* per unit, 3½ units for thirty lifts | | 3½ |
| | 14 | 14 |

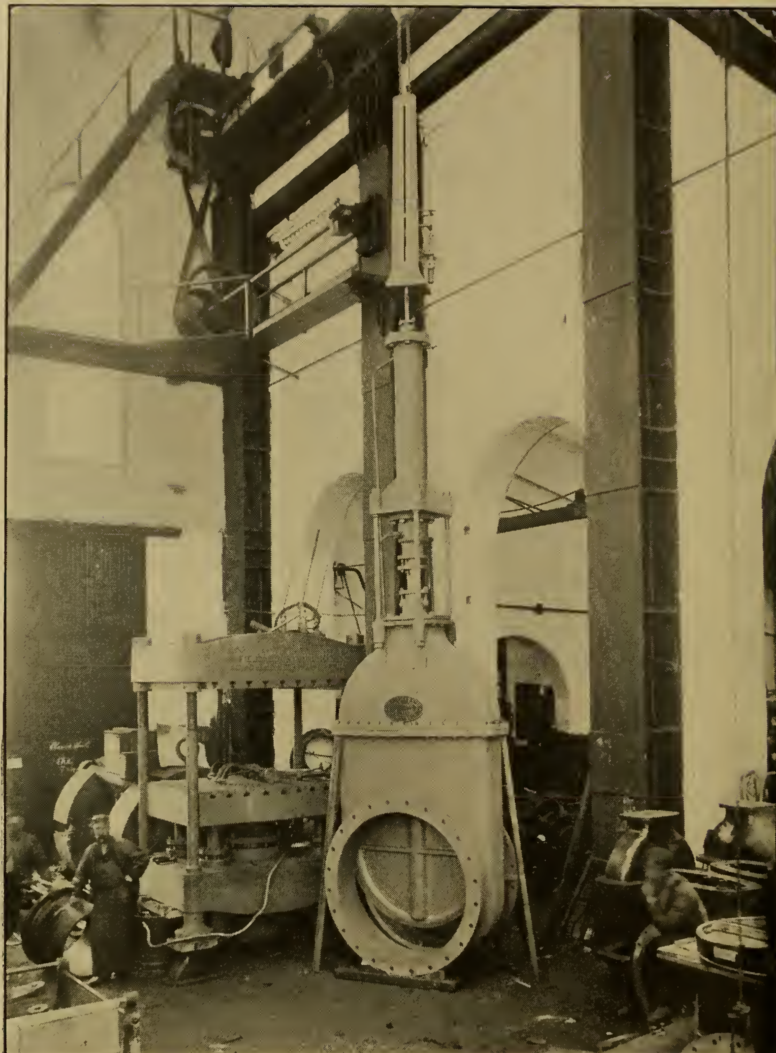
The totals, it will be observed, come out in surprising identity, indicating that, all things considered, there is very little difference between the two systems in point of cost. It is true that we have not included in the statement any item for wages of crane drivers, but this is not likely to disturb the equilibrium. Indeed, it would be difficult to make an actually complete statement comprehending every branch of establishment charges and incidental expenses. But such items would be at least equally divided, and so do not affect the question in so far as it is one of comparison.

That the actual cost of working an electric and hydraulic crane may exhibit a very close approximation to



WESTINGHOUSE ELECTRIC MOTOR OPERATING LAMBERT HOISTING ENGINE AT SEATTLE

coincidence is corroborated in a very striking manner by some figures which were given last summr to the Engineering Conference at Westminster by Mr. W. H. Hunter, the chief engineer of the Manchester Ship Canal. He stated that, in working two parcels, of 160 tons each, by the two systems, the cost, carefully computed, was almost identical. "At the rate of a penny per unit measured at the meter for the electric current, the cost of working electrically was 13.83*d* for the parcel of 160 tons. That included the cost of the plant and ordinary expenses, including maintenance costs. For the hydraulic power, the cost was 13.56*d*—



HYDRAULIC SLUICE VALVE 57 INCHES DIAMETER, OPERATED BY HYDRAULIC CYLINDER.
GLENFIELD & KENNEDY, KILMARNOCK

almost exactly the same." Mr. Hunter admits that, in this instance, the loads presented for each lift (about 25 cwts.) were so uniform as to place the hydraulic cranes at an advantage; but, on the other hand, his figures do not include any allowance for interest and depreciation in regard to the capital expended on the cranes themselves nor for maintenance, in which respects the hydraulic crane would have perceptibly gained ground; so that, all things considered, the comparison is fair and reasonable.

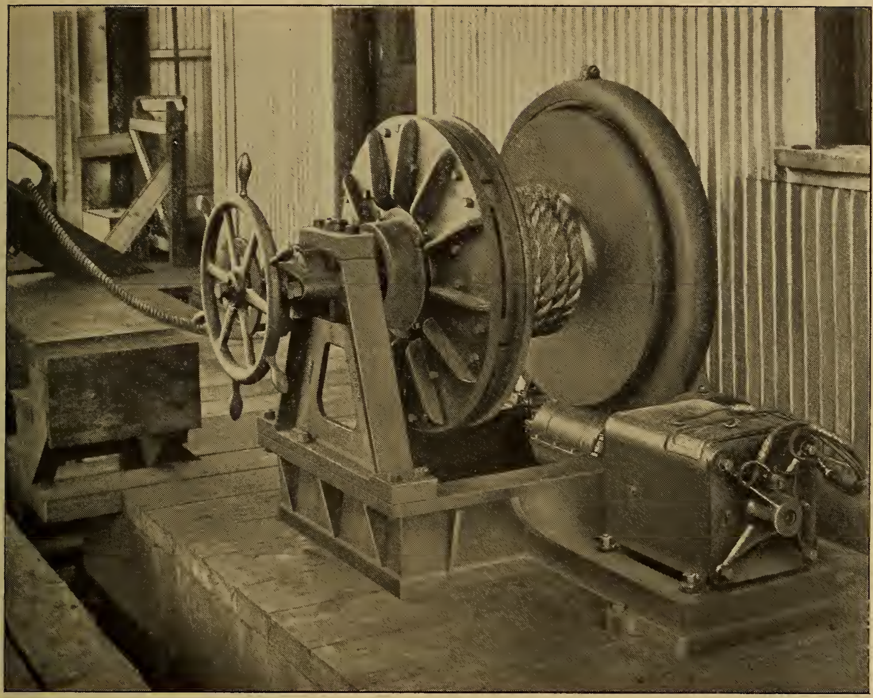
In regard to current expenditure, then, there appears little to choose between a hydraulic and an electric quay crane. Much will, of course, depend upon the rates at which power can be obtained or manufactured in different localities; but it ought to be feasible in any dock system of importance to produce independently either hydraulic or electric power at the rates given. In smaller installa-

ELECTRICALLY-OPERATED COAL BRIDGES OF MILWAUKEE FUEL CO., MILWAUKEE, WIS. BRIDGES BY HEYL & PATTERSON, PITTSBURG. CLAM-SHELL BUCKETS BY THE HAYWARD CO., NEW YORK


TRAVELING SHIP-DISCHARGING ELEVATOR AT PRINCESS WHARF GRANARY, BRISTOL DOCKS; CAPACITY 75 TONS PER HOUR. SPENCER & CO., LTD., MELKSHAM, WILTS

tions the costs will, perhaps, be higher, and with greater disparity between them. At Middlesbrough in 1903, electric power cost 2.02*d* per unit and hydraulic power 12.82*d* per thousand gallons. In 1906 electric power had fallen to 1.8*d* per unit. At Swansea, in 1906, it was 1.27*d*, while hydraulic power there was at the rate of 8.41*d* per thousand gallons. Poplar can produce electricity at less than a penny a unit, and its experience is not by any means unique. As experience is gained, so improvements and economies are effected, and the cost of power falls. Opposite is shown the relationship existing between the systems in point of cost and actual energy value.

In the case under review above, 3½ electric units only were used, as compared with 880 gallons of water. This, of course, is due to the electric crane adapting its supply to the vari-



LIDGERWOOD ELECTRIC HAULING WINCH, AS INSTALLED AT THE PENNSYLVANIA RAILROAD CAR FERRY, GREENVILLE, N. J.

able load, whereas the requirements of the hydraulic crane were invariable.

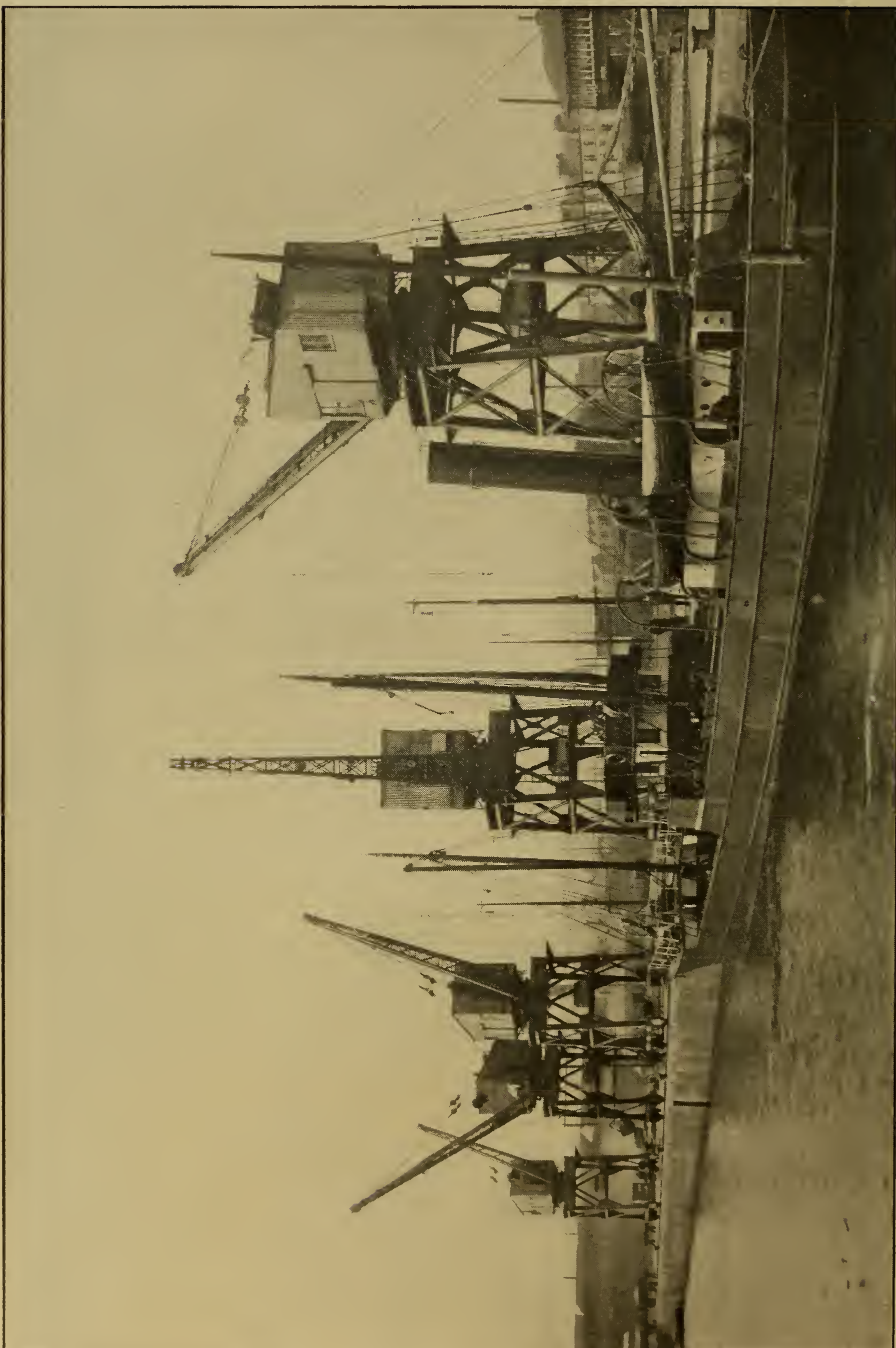
generating station alternately for the supply of power in the daytime and light at night. The balance of advantage lies undoubtedly, on the whole, in favour of electricity for the working of light quayside appliances.

RELATIVE COST OF ELECTRIC AND HYDRAULIC ENERGY PER UNIT (KILOWATT-HOUR)

| | |
|---|---|
| 6½ units of electric energy at 1*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 6½*d* |
| 6½ units of electric energy at 1¼*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 8⅛*d* |
| 6½ units of electric energy at 1½*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 9¾*d* |
| 6½ units of electric energy at 1¾*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 11⅜*d* |
| 6½ units of electric energy at 2*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 13*d* |
| 6½ units of electric energy at 2½*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 16¼*d* |
| 6½ units of electric energy at 3*d* per unit are equivalent to 1,000 gallons of water of 750 pounds pressure at.... | 19½*d* |

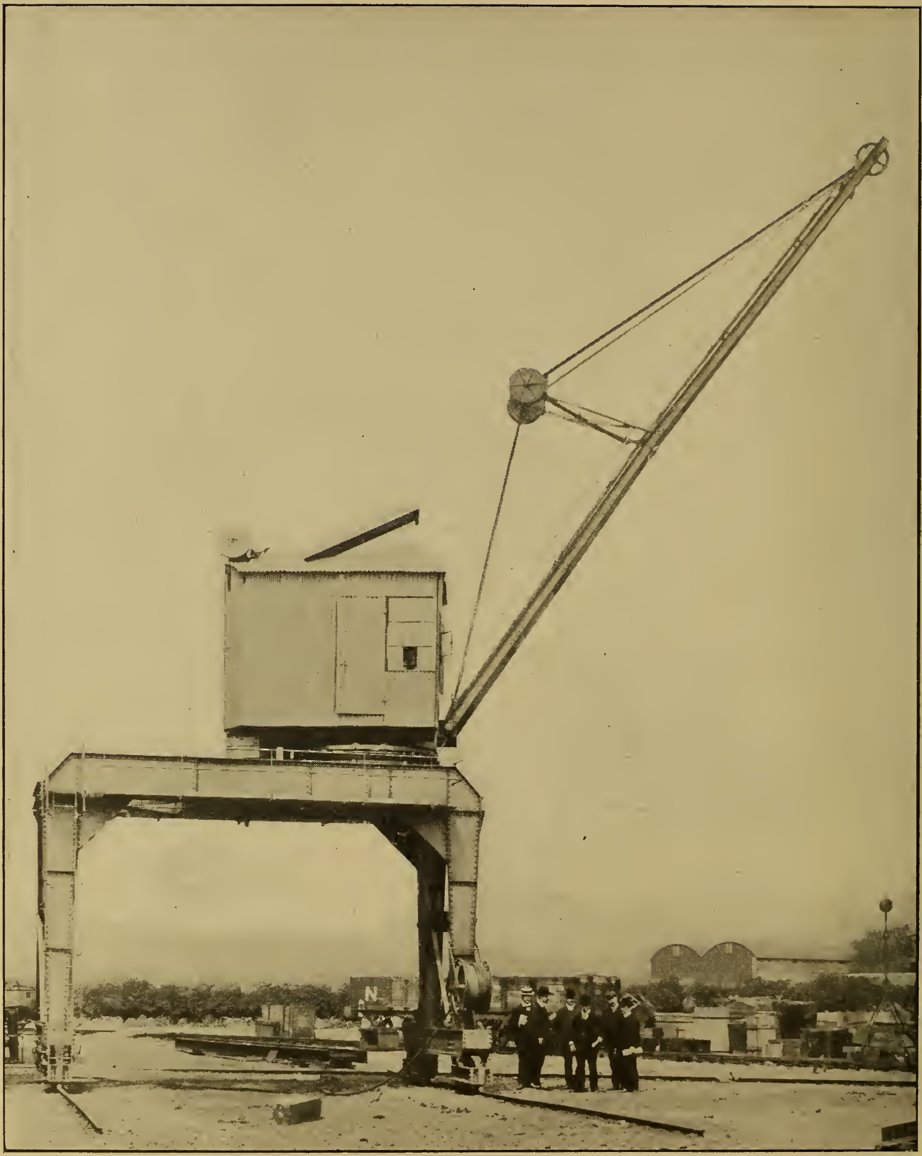
As regards machines of the second class, the question of current expense is naturally of high importance; but other considerations must not be altogether overlooked, and there are several points in favour of an electric system. It is much more adaptable to work of a variable nature, and it lends itself readily to rearrangement and modification in accordance with changing circumstances. Moreover, unlike gate and sluice machinery, cranes rarely require to be brought into operation at night-time, and there is thereby afforded an opportunity of using the

As regards the intermediate group of machines, capstans and light, movable bridges, it may be said that their motive power will be largely determined by circumstances. They can conveniently be actuated by either system, and it will depend principally upon the nearest available source of supply as to which form of power is utilized. Still it may be usefully pointed out that capstans are usually located in pits and situations below ground, where the presence of



ELECTRIC CRANES AT ROTHESAY DOCK, GLASGOW. STOTHERT & PITT., LTD., BATH

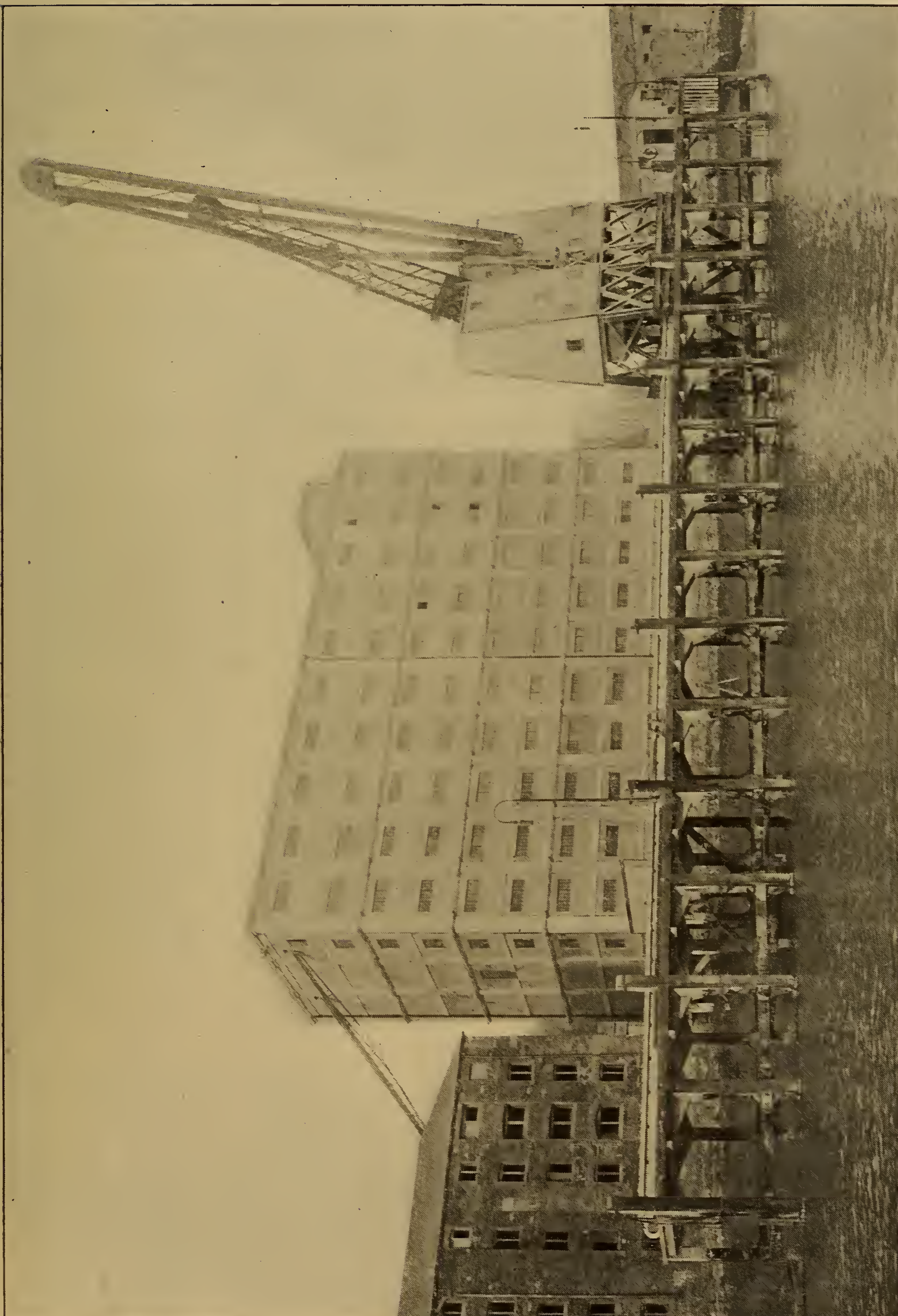
ELECTRIC LOCOMOTIVE CRANE, WITH CLAM-SHELL BUCKET FOR HANDLING COAL, FOR THE NATIONAL SUGAR REFINING CO. THE HAYWARD CO., NEW YORK



ELECTRIC GANTRY CRANE AT FREMANTLE HARBOUR; CAPACITY 3 TONS. APPLEBYS, LTD., LONDON

moisture and water is likely to be deleterious to electric cables and connections, although these can be made waterproof by appropriate treatment at some extra cost. This objection may also apply to some bridges; but, generally speaking, it is not of very great weight, and will hardly affect a conclusion arrived at on other and *prima facie* grounds.

There is one branch of quayside industry to which we have not referred, and which, perhaps, ought not to be altogether overlooked, although somewhat of a special kind and by no means confined to seaports. The handling of grain between ship and granary is a very important feature of harbour work, especially in a country which, like Great Britain, is



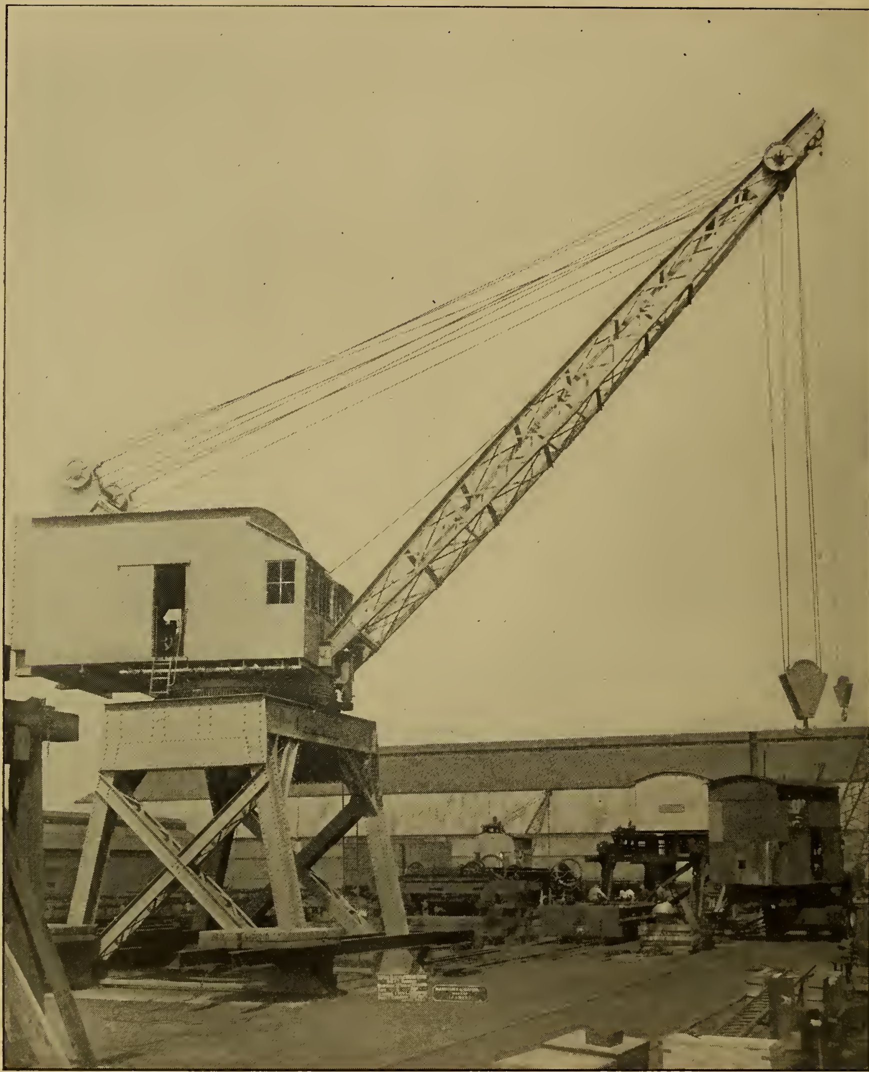
REINFORCED CONCRETE WAREHOUSE OF MESSRS. R. & H. HALL, LTD., WATERFORD, SHOWING ELECTRIC DISCHARGING ELEVATOR OF 100 TONS CAPACITY PER HOUR, BY SPENCER & CO., LTD., MELKSHAM

ELECTRICALLY-DRIVEN BARGE DISCHARGING ELEVATOR AT CLARENCE MILLS OF MESSRS. J. RANK, LTD., HULL. CAPACITY 60 TONS PER HOUR. SPENCER & CO., LTD., MELKSHAM

so largely dependent on foreign sources for its wheat supply. Grain elevators and conveyors, however, are not, properly speaking, port appliances, or rather we may say that they have a wider application than that term implies. In any case, they come under the head of light-running machinery, for which it has been pointed out that electricity offers the most convenient and economical system of working. It is doubtful whether hydraulic power has been adopted for any modern installation in this connection, unless under the most exceptional circumstances. The writer cannot recall any such instance, although he has known it to be used in older installations prior to the vogue of electrical power.

Summing up the whole matter, it can confidently be stated that there is still ample scope for the employment of both electric and hydraulic energy in connection with port and dock work, and while electricity seems to

SHIP-DISCHARGING ELEVATOR TAKING GRAIN FROM VESSEL AND DELIVERING TO TUNNEL CONVEYOR UNDERNEATH QUAY. BUILT FOR MESSRS. J. RANK, LTD., BY SPENCER & CO., LTD., MELKSHAM



FIXED ELECTRIC WHARF CRANE. CAPACITY 30 TONS AT 40-FOOT RADIUS. RANSOMES & RAPIER, LTD., LONDON AND IPSWICH

have been gaining ground rapidly at the expense of its rival, this is only due to the fact that it is taking up a position of equal importance which has rightly belonged to it from the very first. For the future, the field lies open to both systems to extend their influence along the lines of their natural development, and there is little prospect, so far as can be seen at present, of either of them gaining absolute possession and control.

# MECHANICAL FEATURES OF THE FRANCO-BRITISH EXHIBITION

By a Staff Correspondent

SO far as concerns machinery this exhibition cannot be said to be in any sense truly representative of the industry of either France or Great Britain, but it is one rather of a general type with exhibits from the colonies of both countries, that do at least give pause for thought as to the great amount of work of an engineering nature that remains to be done before the vast resources of these many colonies can be at all adequately developed. As a colonial exhibition, therefore, there is much of interest in this show. Canada, of course, comes an easy first of the British Colonies, first because of her greater age, for this year marks the founding of Quebec, three centuries ago; first also because her propinquity to Europe, especially during the sailing-ship era, placed her at an advantage in respect of immigration, and first because in her borders she marks that fusion of the French and English races which had its first example in England in the eleventh century, and emphasizes the idea of the Franco-British entente which has underlaid the scheme of the exhibition. Canada, indeed, makes a goodly show of the great natural and industrial resources of the great dominion. The Canadian pavilion measures 350 feet by 150 feet, and takes the shape of a central hall with aisles and pillars, and the decorative scheme is in the form of mural decorations representing trees but composed of wheat straw. The exhibits are classified under the head of Agriculture, Horticulture, Forest Products, Economic Minerals, Animals, Dairy Products and Fisheries. In all these items Canada holds a high place. She has immense areas of wheat-growing lands, and there is still time to organise her forests on such a basis that their product of timber shall be continuous and everlasting. Canada may indeed profit by the lesson afforded her by the poor forestry to the south of her, for the United States have destroyed their forests, little dreaming that the population would ever grow large enough to cope with their vast immensity. Canadian agriculture has caused to spring up a fairly extensive manufacture of implements and machinery, while the product of her forests has equally tended to the establishment of saw mills and of furniture factories. Important as are these two items there is not less importance to be attached to the mineral wealth of the country, for there are few economic minerals and metals that are not found in Canada. Cobalt particularly is a product in which Canada stands preeminent, asbestos is another product of special interest to the engineer, while the electrical industry finds in the mica of Canada a product which it could ill spare.

The wild animals of the Dominion lose the predominant position they once held when Canada was hardly known except for furs, but the pond with a colony of live beavers attracts great attention.

These various activities, together with the dairy and fruit and canning industries, form a foundation on which a large and progressive manufacturing industry has been built up of heavy engineering carried out in Canada. We need only refer to the General Electric Co., of Peterboro, whence came the great generators at the latest Niagara power station, and the Turbine Wheel factory at Montreal,


YORKSHIRE IRON AND STEEL PRODUCTS, EXHIBITED BY TAYLOR BROS. & CO., LTD., LEEDS

which supplied the turbines for the new dam at Montmorency, of the Quebec Light & Power Co. It is to be noted that this very representative Canadian exhibit is conceived in no narrow sense, for there is nothing to mark local and provincial features. The exhibit is Canadian and shows Canada's productions as a whole.

This has hardly been the case with the Commonwealth of Australia. Here there is a common building, but it is semi-divided by the semblance of screens or archways into courts for each State. Australia has too recently been federated perhaps to permit of the entire elimination of the provincial feeling which is by no means always a good feeling, and in the form of States' rights, may, as all know from the history of the United States, end in trouble.

New Zealand, which still lies outside the pale of the Commonwealth, has her own pavilion, but New Zealand shows no trace of the nine old provinces into which she was once politically divided, and makes a whole-colony show after the manner of Canada.

Australia, however, makes an excellent show and the division into courts is as hardly perceptible as we may hope soon will be the local feeling. Still, the various States, New South Wales, Victoria, Queensland, South Australia and West Australia are so alike generally that their exhibits show a good deal of overlapping, and one gold trophy would do better as a sign of Australia's gold-mining industry than the several separate ones.

With but little alteration, the words applied to Canada would serve to describe the products of Australia, for though so different in climate on the year's basis, the summer climate of Australia is by no means so greatly different from that of Canada, and the resources of the two countries are remarkably similar, though Australia is

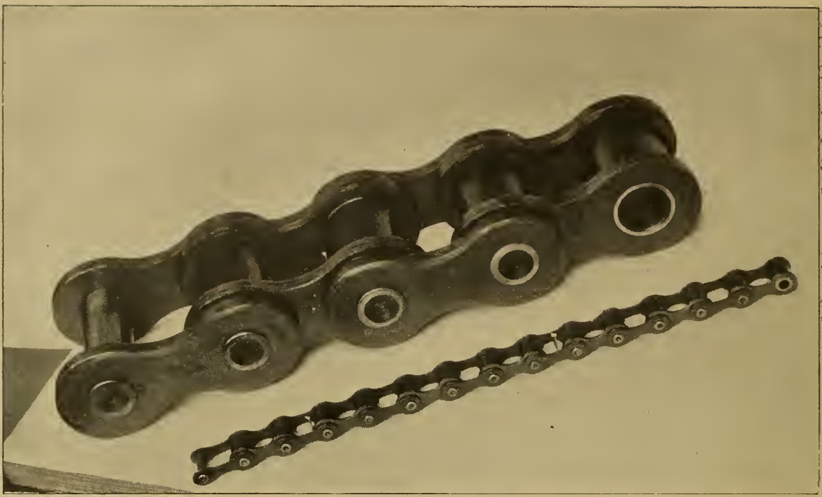
not a land of fishing industry like Canada.

To the engineer the cotton exhibited from Nigeria by the British Cotton Growing Association cannot fail to be of interest as a possible future supply of raw material for the greatest of England's manufacturing industries, and therefore one that provides work for engineers and machine makers. Though perhaps a short staple, there is always the possibility of improving this by the careful selection of seed and suitable cultivation. But the fiber is good, and it is clean, as shown in the bale, and there is ample evidence in this exhibit that good cotton can be grown in Nigeria and the samples of yarn spun from it are excellent proof of this. Indeed, very fine counts have been spun and are here shown in the cop. Cotton fiber is also shown by Mauritius and by the French-African Colonies, and also in the Indian pavilion.

Turning to exhibits of a more immediately mechanical nature, these are very largely composed of models of railway stations, locomotives, warships, mercantile vessels and other things, and therefore very much cannot perhaps be said for this as a machinery exhibition, for it is by no means representative. Two locomotives, for example, are all we found; namely, the "Invicta," the first locomotive of what is now the Southeastern Railway, and a modern engine that this same company built at their Ashford shops, a fine piece of work. The "Invicta" very much resembles the original "Rocket," and it was built by the same firm of Stephenson. There are some good exhibits of steel forgings, armour plate and other heavy manufactured steel in the shape of crank shafts, gun tubes, and one very fine longitudinally-cut ingot of fluid compressed steel. The many models of ships in both the French and British sections attract much attention; they are beautiful specimens of model work. An interesting exhibit is that of Taylor Bros., of Leeds, for it includes articles of Yorkshire iron. Reference has more than once been made in these columns to the fact that for certain purposes the best Yorkshire iron more than holds its own with steel. In axles for railway vehicles Taylor's name is world wide, and their wrought-iron locomotive axles are exported to the United States, as also are their staybolt bars. Wrought iron is not a homogeneous substance, but is rather a bunch of compacted fibers of iron separated by some other substance, and being such, cracks do not easily travel through it as they do through homogeneous steel. Hence the use of wrought iron for axles, bolts, draw-gear, crane hooks and all purposes where price is of less importance than an absolute safety. In Staffordshire, the home of chains and anchors, the same safety is sought by the use of wrought iron, and the British Navy trusts to Staffordshire for its anchors and chain cables. But Staffordshire appears but scantily represented, and beyond the exhibit of Alfred Hickman, Ltd., of forge and foundry and basic pig iron, ores, steel sections, etc., we find little of the county beyond fire-clay goods.

In small items, the chains of Hans Renold should be noticed. These driving chains and wheels are coming into very considerable use, especially for short drives, where a belt would be unsuitable even if strong enough. Recent years have seen supplied annually for general engineering purposes chain drives to transmit over 30,000 horse-power.

The exhibit includes patent silent chains, bush roller chains, block, stud, balance, textile, pipe wrench and other special chains, as well as cycle chains. In several cases the parts of the chains are displayed separately, so as to show the construction. The complete chain drives shown include sizes for powers ranging from 3 to 40 horse-power, and speeds from 400 to 1,300 feet per minute. In the silent chain drive is included a spring wheel, part of the cover of which is cut away to expose one of the springs. This special form of wheel is used for drives



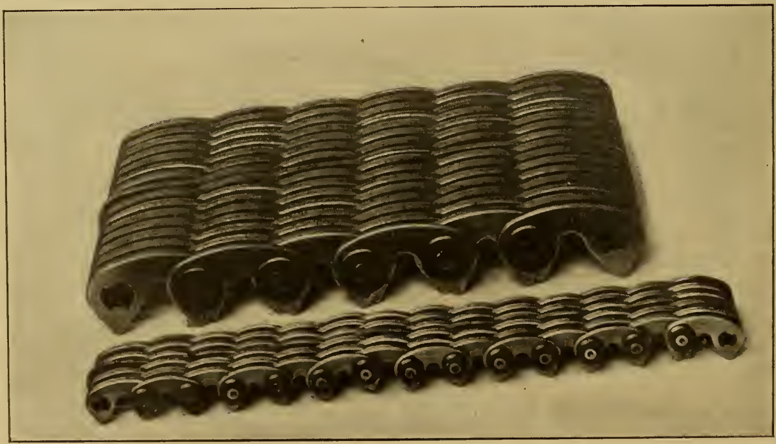
DRIVE CHAINS, EXHIBITED BY HANS RENOLD, LTD., MANCHESTER

where the load is impulsive, as in pumps, compressors, forging machines, etc.

The big shipbuilders are perhaps fortunate, for no one expects them to send actual ships, and indeed a model can be viewed in toto and a ship cannot. Models are shown by Armstrong, Whitworth & Co.; dredger models by Fleming & Ferguson, and Berthon boats by the company of that name. Wm. Denny & Bros., of Dumbarton, show ship models and passenger steamers. Yarrow & Co. and Thornycroft exhibit torpedo boats and shallow-draught steamers.

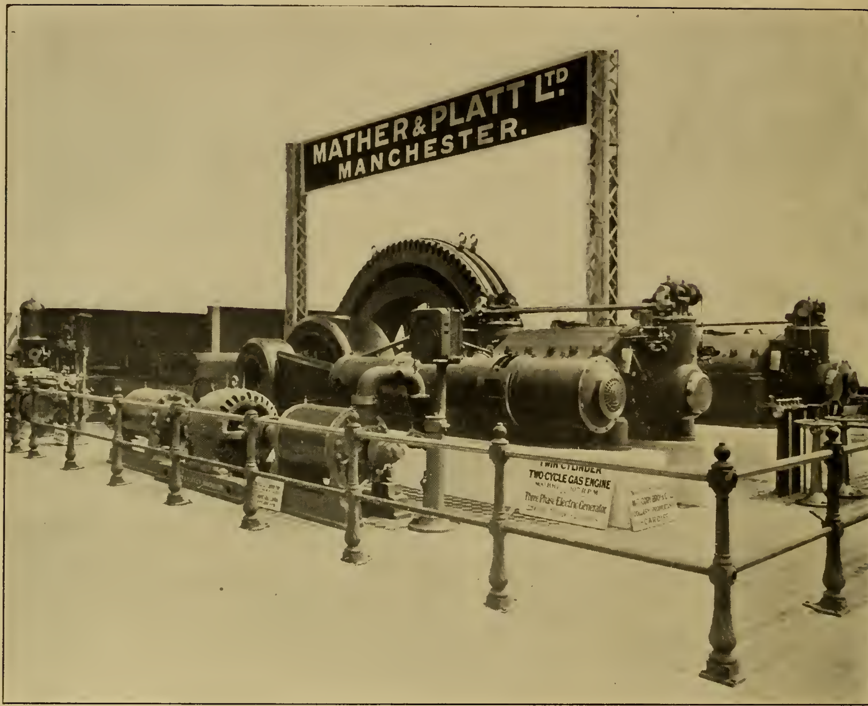
A full model of the R.M.S. *Hound* is shown by G. & I. Burns, and eight models are shown by R. & W. Hawthorn, Leslie & Co., of Newcastle. Hopper and other dredgers are shown by Wm. Simons & Co., of Renfrew, and a large number of models also appear at the stand of the Fairfield Co.

Nor are the steamship companies behind, and we note the Booth Line, the Pacific Steam Navigation Co., the Royal Mail Steam Packet Co., the Anchor Line, the Union Castle Co. and others with models of mail and other steamers. Other firms who show models incidentally, only, are John



EXHIBITS OF SILENT-DRIVE CHAIN. HANS RENOLD, LTD., MANCHESTER

LARGE STEEL PLATE, SHOWN AT THE FRANCO-BRITISH EXHIBITION BY THE SOUTH DURHAM STEEL & IRON CO., LTD., STOCKTON-ON-TEES




GAS ENGINE EXHIBIT OF MESSRS. MATHER & PLATT, LTD., MANCHESTER

Brown & Co., Ltd., with the *Lusitania* and other well-known ship models. Harland & Wolff with the *Cedric* and others, Wm. Gray, of Hartlepool. Some of the models, indeed many of them, are beautiful specimens of work, and the same applies to the models in the French section, wherein are many warship models; notably the well-known firm of Normand et Cie. and the Société de Saint Nazaire, the Société de Provence and the Société des Batignolles. French mechanical work differs a good deal from British in many respects, not always to the Englishman's advantage, though often so. In any case it is always instructive to be able to compare and to note how a Frenchman will approach a problem from a different viewpoint. The French have always had an excellent reputation for good shipbuilding, and it was always the case that one of the old wooden ships could outsail an English ship, and some of the best ships in the British navy were French built. Perhaps to-day the same degree of superiority is not apparent, but the French-Atlantic boats seem to make excellent time with but little fuss. In civil engineering and in map making the French excel, French maps being very beautiful. Many will be found in various parts of the exhibition.

Many visitors will probably never find the range of buildings which lie between the main buildings and the Uxbridge Road entrance, but they should find these, for there is much of interest in these buildings.

There is shown by the South Durham Steel & Iron Co. the largest steel plate ever rolled, and generally there is a fairly good and comprehensive exhibit of steel work by such firms as Cammell, Laird & Co., John Brown & Co., Thos. Firth & Sons, W. Beardmore & Co., David Colville & Sons, John Spencer & Sons, Wm. Whitwell & Co., the Monkbridge Iron Co. and the Glengarnock Iron & Steel Co.

The Northeastern Steel Co. and Dorman Long Co. are also present

with rolled-steel sections, the former showing tram and conductor rails, blooms, billets, pit props, etc., and the latter chiefly structural iron.

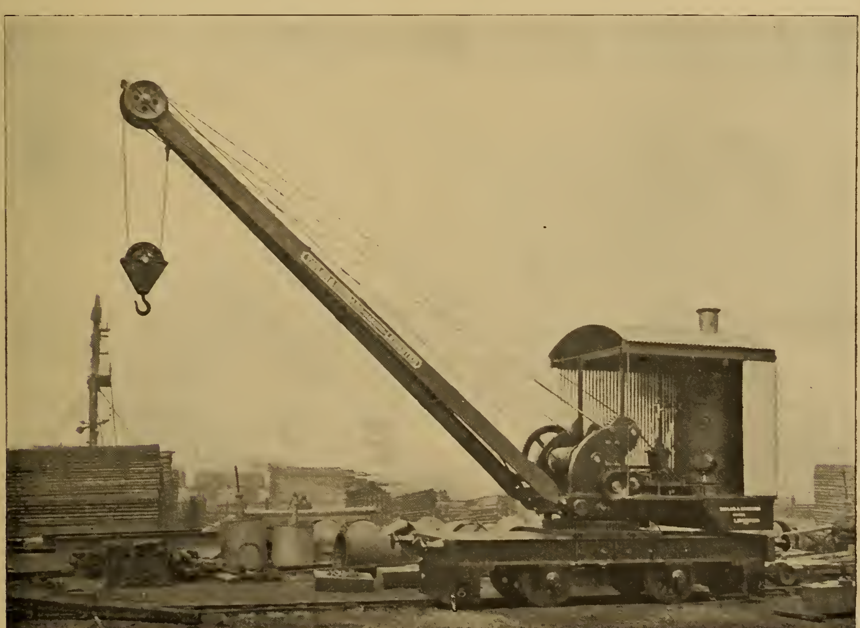
The electrical section is distinctly paltry, and in the catalogue there are only seven names, and all of these cannot be termed strictly electrical.

In the machinery section about the most important things shown are the Westinghouse Company's vertical gas engine and continuous-current generator of 500 kilowatt and the Körting type gas engine of Mather & Platt. The former is, we understand, to be run by gas generated by a plant of 2,000 horse-power capacity, which has been laid down by the Power Gas Corporation to work on the Mond system

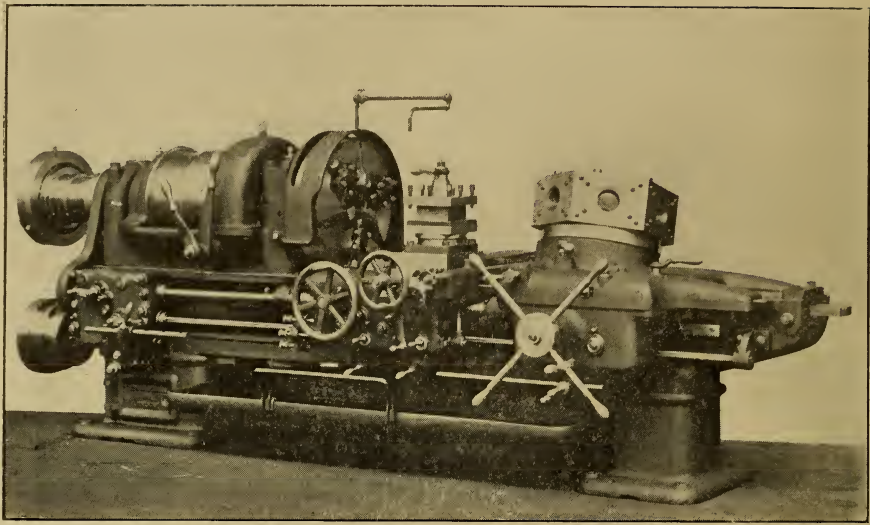
The gas engine of Mather & Platt is a double-acting double-cylinder engine, of 800 horse-power, with the separate gas and air pumps that distinguish this design. Other gas engines are those of the National Gas Engine Co., of 100 horse-power and engines by Crossley Bros. There is really no exhibit in steam generation if we except the boilers of the Babcock & Wilcox Co., of the Niclausse Co. and the economizer of the Clay Cross Co.; there are three 7-ton steam cranes by Grafton & Co., Taylor & Hubbard and Applebys.

Though of small extent, the display of machine tools is fully proportionate, Humpage, Thompson & Hardy showing a 32-inch high-speed gear-hobbing machine, and such firms as Alfred Herbert, Ltd., John Holroyd & Co., Joshua Buckton Co., show machine tools of ordinary and special types. Messrs. Herbert, of course, show automatic screw machines, and Messrs. Holroyd, gear-hobbing machines and worm and wheel-cutting machines. The most noticeable machine is perhaps the high-speed planer of Messrs. Buckton & Co., in which the platen is brought to rest by the compression of a powerful coil spring which serves also to help the platen to start rapidly on its return stroke.

In the science section the exhibits are very largely historical in the way of representing progress along various lines, as for example in microscopes, which are exhibited in considerable

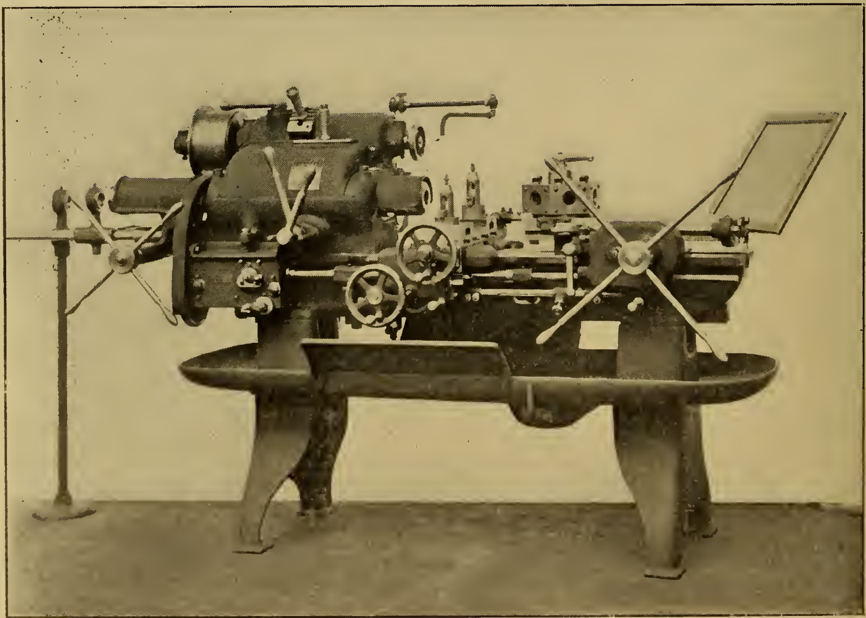


LOCOMOTIVE CRANE AT FRANCO-BRITISH EXHIBITION. MESSRS. TAYLOR & HUBBARD, LEICESTER

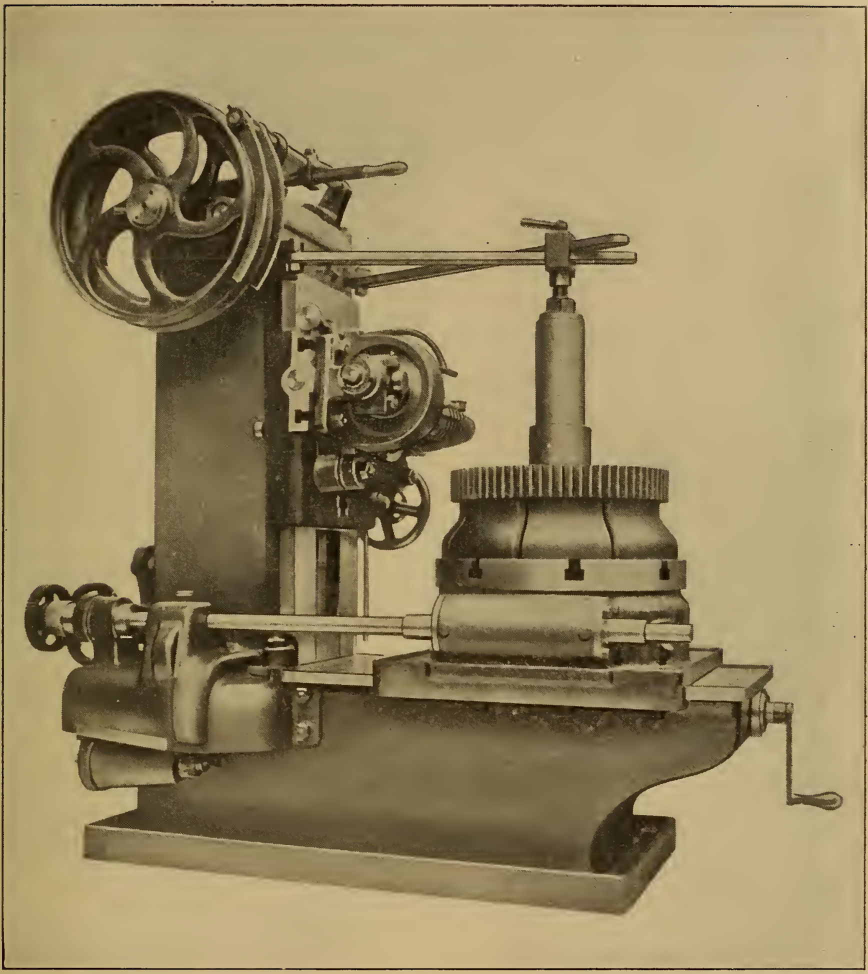


INCLINED TURRET LATHE. ALFRED HERBERT, LTD., COVENTRY

numbers to mark the progress of this instrument. In new work the Cambridge Scientific Instrument Co. show electrical thermometers, pyrometers, indicators and recorders of various kinds, also calorimeters. In the heat section the apparatus used by Joule to determine the mechanical equivalent of heat is shown. The whole science court is interesting, but too numerous in contents for any detailed reference, but engineers will find interest in the ordnance-survey section, where are shown maps in progress and generally



TURRET LATHE, SHOWN AT THE FRANCO-BRITISH EXHIBITION BY ALFRED HERBERT, LTD., COVENTRY

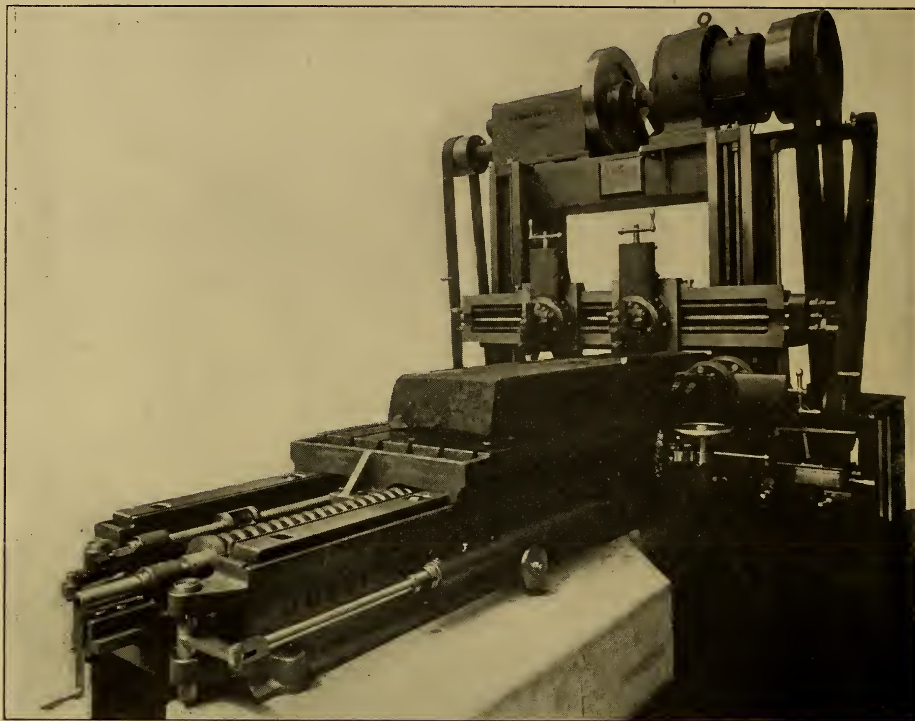


HIGH-SPEED GEAR-HOBBING MACHINE. HUMPAGE, THOMPSON & HARDY, BRISTOL

the process of map making as practiced by the British Government Ordnance Survey.

Beyond the Parsons turbine there is little to be seen of note in the way of steam engines. Indeed, gas power is decidedly the predominant partner here. But Allans, of Bedford, show two high-speed steam engines, one a three-cylinder compound enclosed forced-lubrication engine of 450 brake horse-power with one 16-inch high-pressure and two 18-inch low-pressure cylinders, all with a stroke of 10 inches and a speed of 400 revolutions per minute. The other engine is of 220 brake horse-power at 450 revolutions and has cylinders 13½ and 19 inches with a stroke of 8 inches. This firm also show two of their make of Edwards air pump, and a large surface-condenser tube-plate, with 3,751 tube holes. This plate is 88 inches diameter and 1½ inches thick. A four-stage turbine pump is shown directly connected to an electric motor and of a capacity of 100 to 120 gallons per minute at 1,700 revolutions against a head of 200 to 250 feet.

Enormous as is the production of tinplate ware, few engineers have seen much of the machinery by which



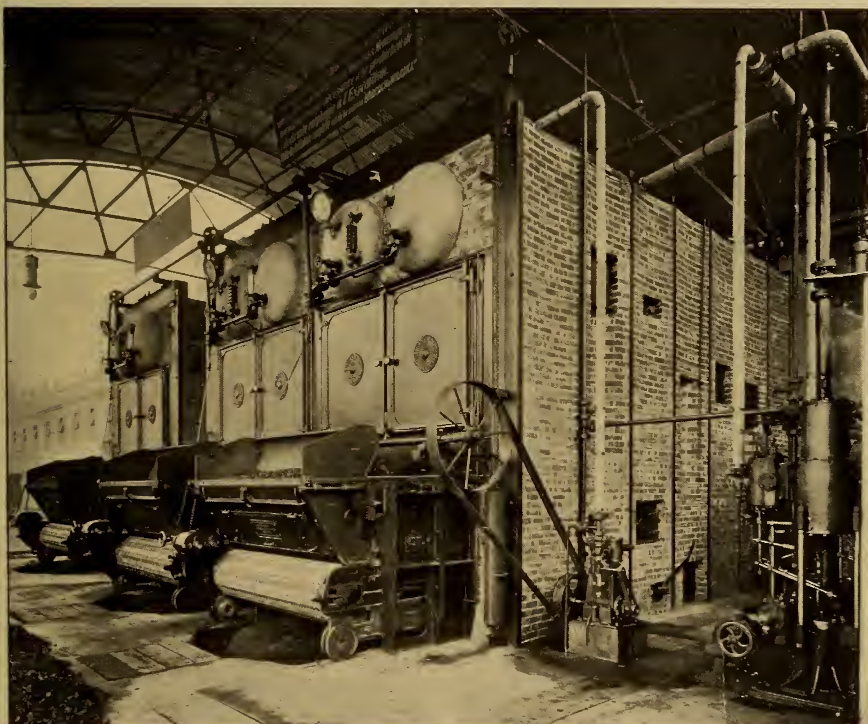
HIGH-SPEED REGENERATIVE SPRING PLANING MACHINE. J. BUCKTON & CO., LTD., LEEDS

tin canisters are made. But this they can find at the stand of E. W. Bliss & Co., on the French side of the Machinery Hall, an American firm naturalized in Paris. This firm show a double-seaming machine for the closing of full tins of fruit or other articles. The tin is held still while being seamed, so it does not lose contents by whirling action. In doing circular work the machine will turn out as many as fifty closures per minute or even more when a less degree of tightness is required, as for dry stuff like tea or flours. The various sheet stamping and other machines of this firm will be found very interesting. It is to be noted that in the dry closing of tins, by which of course we mean without solder, there is applied to the parts to be seamed or rolled together a paste or paint which is tightly folded in the seam.

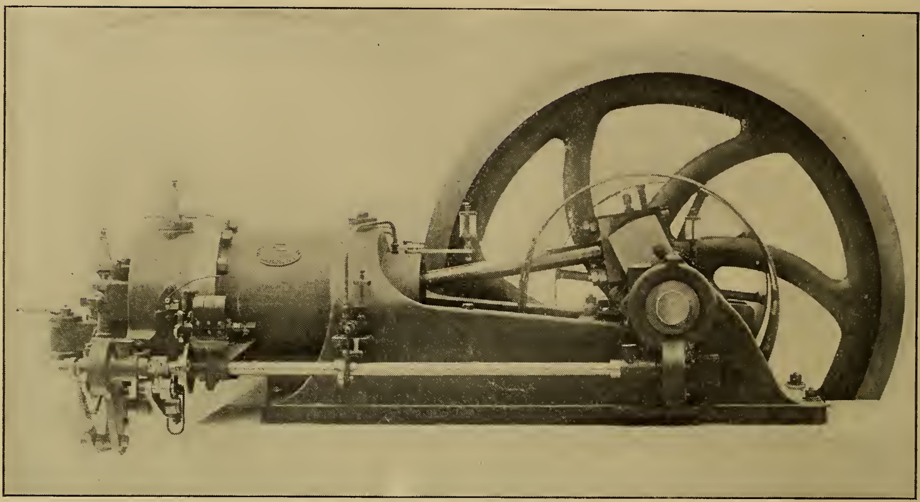
To revert, however, to the steam exhibits, now that the Babcock boilers have been set to work, the Parsons turbine may be seen driving 1,800 kilowatt electric generators. These generators are placed at the same end of the turbine shaft and may be found near the large Westinghouse gas engine. In order to reduce blade stripping to a minimum the blades are made thin at the extremity and are fitted in sections or combs in place of being individually inserted. Just regulation is provided, and the present installation embodies the latest practice and design in this class of turbine. Similar sets have been installed at the electric-light stations of Derby, Manchester, Marylebone and Newcastle. A comparatively new firm of gas engine makers, John Cameron, Ltd., of Salford, are here with a 60 brake horse-power gas engine. It is of plain and substantial design for 235 revolutions per minute and will develop 50 brake horse-power on producer gas, the larger power named being that given with gas of 650 B. T. U. per cubic foot. We think, however, that

all engines ought to be more particularly rated on gas of low calorific power. Large engines beyond, say, 500 horse-power might be rated on gas of 100 B. T. U.; engines of 20 to 500 horse-power on gas of 150 B. T. U.; while smaller engines alone should be rated on town's gas of 650 B. T. U., for one does not use illuminating gas except in small engines. A good feature in the engine is that the crank shaft is made of high-class steel, if this means high-tenacity steel, a material often advocated in these columns for engine shafts in preference to yielding mild steel, which is by no means suitable for crank shafts. This firm has long been known as pump makers and is showing pumps also, one of three-throw type having rams 6 inches by 8 inches and will throw 9,000 gallons per hour under a 200-pound pressure per square inch; that is, against a head of 465 feet. Its speed is 70 revolutions per minute and it is belt-driven through machine-cut cast-iron gears.

Though not novel, the driving system of the hydro-extractor as exhibited by Messrs. Broadbent & Sons, Ltd., is instructive and might well be extended to other uses. The electric motor rotates freely on a sleeve which is independent of the cage spindle. The sleeve carries friction shoes which press centrifugally on a part of the cage carrier, and the friction of the shoes when rotating at normal speed is equal to the power of the motor. Thus the motor can turn freely and the cage is gradually brought to speed without risk to the motor, which is saved overheating. The rotating cage of a hydro-extractor at full speed has an enormous stored energy, and without such a device is by no means an easy thing to put in motion. These friction clutches do it perfectly and



BABCOCK & WILCOX BOILERS, WITH SUPERHEATERS AND CHAIN-GRATE STOKERS AS INSTALLED AT THE FRANCO-BRITISH EXHIBITION



HORIZONTAL GAS ENGINE, 60 HORSE-POWER. JOHN CAMERON & SON., MANCHESTER

they have no wedge-gripping action such as might cause seizure. They act purely by centrifugally-generated dead-pressure friction.

In heavy forging may be noted the model of the turbine rotor of the *Lusitania* at the stand of John Brown & Co., Ltd. The actual forging weighed 24 tons and was 11 feet 8½ inches outside diameter; 11 feet 4 inches inside, and 8 feet 2 inches long. A gun tube of 16½ tons is shown. It is 48 feet long and 2 feet 10¾ inches diameter at the large part, and is for a 12-inch gun. An armour-plate steel roll and some tested 16-inch armour plate and other steel articles are to be here seen, notably a longitudinally-cut Harmet fluid compressed-steel ingot, and the furnace of a marine boiler


MOND GAS-PRODUCER PLANT, SHOWN BY THE POWER GAS CORPORATION, LTD., LONDON

which has collapsed from overheating without tearing the material or even cracking. David Colville & Sons, Ltd., show a steel plate which measures 69 feet by 87 inches, is one inch thick and weighs more than 9 tons, while another plate of equal thickness and 8½ tons in weight measures 67 feet by 84 inches. Other articles in pressed-steel channel bars, castings, piles, etc., are to be seen here.

In steel tubes of long length the exhibit of the Mannesmann Co. at the back of the machinery hall out of doors may be noted. These tubes are coated with preservative composition and clothed with wrapping, and are said to be excellent and desirable substitutes for much heavier cast-iron pipes. Other tubes here are the well-known coiled flexible metallic tubing, and there are copper tubes from Allen, Everett & Co., of Smethwick, and exhibits of steel by John Spencer & Son, Alf. Hickman, Ltd., and Bolckow, Vaughan & Co., Ltd., The Glengarnock Iron & Steel Co. and the South Durham Steel Co., of Stockton.

The section of Transportation is limited in extent, and beyond the big locomotive mentioned and the old "Invicta," locomotives appear only as models, but there are two full-size railway passenger coaches and a model of a station of the London & North-western Railway Co. with model engines and cars in process of shunting. This, like all other working models, attracts much attention.

The textile section is practically confined to manufactured articles. There is very little machinery excepting a few hand-worked looms. But there is an actual working Northrop loom at work. In this loom there is a circular cage of "readied" cops, which, when the shuttle cop has run out, are automatically changed into the shuttle while the loom is in full work. The motion which does this is simple and ingenious, and the loose end of the new thread which hangs from the selvedge is cut off by a special device. Sinkers in the harp thread stop the machine should a harp thread be broken, the movement being somewhat like the stop motion of the drawing frame. This Northrop loom is worth study. It is being exhibited by Wm. Hollins & Co. The Damask loom, with its Jacquard motion and cards, is interesting, of course, and so is the hand loom on tweeds, etc., and the knitting machines. But why not have had a full complement of cotton or wool machinery, as was done at Manchester in 1887? We can only regard this present exhibition as an indication that machinery makers and engineers are tired of exhibiting, for this one is, to say the least, scanty and by no means an indication of the engineering productions of either France or Great Britain.

# ELECTRIC WAVE DETECTORS IN RADIOTELEGRAPHY

By Dr. J. A. Fleming, F. R. S.

EVERYONE who has the smallest acquaintance with the principles of radiotelegraphy understands that the electromagnetic waves or impulses sent out from the transmitting station produce in the antenna or air wire of the syntonic receiving station electric oscillations which are feeble alternating electric currents of very high frequency. As these oscillations cannot be directly appreciated by the senses, some means have to be employed to reveal their existence, and, in turn, to cause them to operate some form of telegraphic or telephonic apparatus, by means of which a visible or audible signal is made, which can be interpreted as an alphabetic sign or else actually heard as an articulate sound.

These devices are generally known as oscillation detectors.

The earliest of these was the well-known metallic filings coherer invented by Branly, applied by Lodge for electric-wave detection, and improved by Marconi into a highly sensitive and practical form for telegraphic purposes. Its drawbacks are the necessity of continually tapping it to preserve it in a condition of sensitiveness or high resistance. Great attention has, therefore, been given to the invention of forms of automatic detector which are capable of more rapid operation. Of whatever type it may be, an oscillation detector is essentially only a very sensitive form of alternating-current galvanometer or electrometer, which, however, may or may not be metrical. Another, and perhaps more important, classification is into idiostatic or heterostatic types. In the first class we place all those forms of oscillation detector which make use of no other auxiliary source of energy, but are set in operation solely by the energy of the oscillations traversing them. Thus, for instance, if we pass the oscillations through a fine wire, which is thereby heated, and detect and measure its rise of temperature by a thermoelectric junction or by the expansion of the wire, the indications are due only to the energy of the oscillations. In the second class of detector the oscillations are made to release some other form of potential energy which operates the actual receiving device. Thus, in the simple coherer and associated battery and telephone the sound produced in the telephone is due to energy taken from the battery, but released by the oscillations by a trigger action. There can be no doubt that this last class of oscillation detector is the most sensitive, but the idiostatic type has generally the most simplicity.

Amongst the novel forms of detector belonging to the self-operated type the crystal rectifiers are particularly interesting. It has been known for thirty years or more that certain crystals have a unilateral conductivity for electricity, and conduct much better in one direction than in another. As far back as 1874 Prof. F. Braun, of Strasburg, found that this was the case for certain metallic oxides and sulphides, such as iron pyrites, galena, and copper-antimony sulphide, and also for psilomelan, a hydroxide of manganese.

The matter, however, remained a physical anomaly not completely explained.

In 1906 General H. H. C. Dun-

woody, of the United States Army, discovered that crystals of carborundum, an artificial carbide of silicon produced in the electric furnace, was capable of acting as a detector of electric oscillations, and the matter has recently been carefully examined by Prof. G. W. Pierce at the Jefferson Physical Laboratory, Harvard University, U. S. A. He finds that a crystal of carborundum, when held between metal clamps or provided with electrode surfaces by platinizing parts of the surface, exhibits a most remarkable one-sided conductivity. Thus, under a continuous E.M.F. of 10 volts, the current through one crystal was found to be 100 times greater in one direction than the other, and in another case under 30 volts the current was 4,000 times greater in one direction than the other. Hence, when subjected to an alternating E. M. F. the crystal rectifies the current and passes only the oscillations or current movements in one direction. Accordingly, if such a crystal is included in a circuit comprising a condenser and inductance, the latter being one coil of an oscillation transformer, the other coil of which is included in the antenna (see Fig. 1), and if the crystal is shunted by a telephone, then when trains of electric waves fall on the antenna a sound is heard in the telephone. For in this case each train of oscillations consists of a series of rapid alternations of current. All the currents in one direction pass through the crystal, but those in the opposite direction are stopped and pass through the telephone coils. Hence, if the trains succeed each other, say, at fifty per second, the telephone is traversed by rushes of current, which are intermittent, and it, therefore, emits a sound.

Prof. Pierce has found that, besides carborundum, a number of other crystals possess the same properties. For instance, hessite, which is a crystalline form of telluride of silver, and anastase, which is an oxide of titanium, exhibit the same peculiarity. General Dunwoody has also discovered that magnetite, or ordinary loadstone, has a similar property.

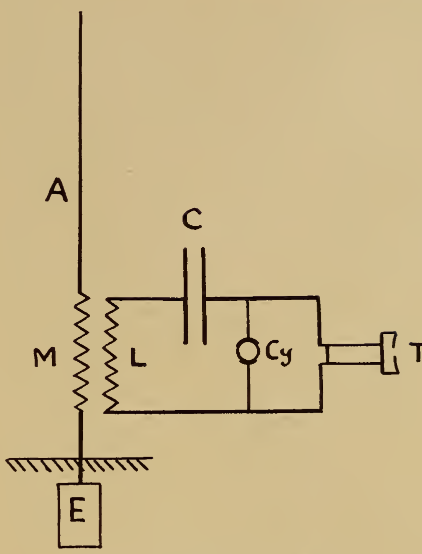


FIG. 1.—CARBORUNDUM DETECTOR

Prof. Pierce's investigations seem to show that the origin of this singular unilateral conductivity is not to be found in thermoelectricity.

The writer of this article, however, ventures to put forward a suggestion, merely as a working hypothesis, which is based on modern views of electric conduction. According to the electronic hypothesis of electricity, conductivity for electricity depends upon the presence of free electrons or negative ions or corpuscles, to use Prof. J. J. Thomson's term, in the body. In addition to chemical atoms of the metal, there are these free electrons which move between them, or, according to one view, jump from atom to atom. The best conductors are the metals, and their atoms are electropositive, and, therefore, have a tendency to lose electrons. Hence, in a mass of metal we must suppose that electrons are continually escaping from some atoms and being taken up again by other atoms; but at any instant there is a certain free population of electrons. These free electrons cannot

easily escape from the metal as a whole, because if they did they would carry with them a negative charge and leave the metal positively electrified, which would create a strong attraction, tending to hold the electrons back. Nevertheless, if the metallic mass is highly heated, electrons can escape from it, because their kinetic energy then gives them such a velocity that some at least are flung out beyond the attraction of the mass. If the electrons drift as a whole in one direction through the metallic mass, this constitutes an electric current, and a current is therefore produced in a conductor by any cause which tends to diminish or increase the number of free electrons at any one point, for then they tend to diffuse from the place where the concentration is greatest to places where it is less, and it is this drift which creates a so-called electric current. Accordingly, electric conductivity depends upon the power of electrons to leave the atoms and enter them again freely.

Suppose that the conductor consists of atoms wholly of the same kind; then there is nothing to prevent an equally free drift of the electrons passing from atom to atom in all directions. Suppose, however, that the conductor in question consists of complex molecules, say, of a metallic oxide or sulphide. The atom of oxygen or sulphur and the non-metals generally are electronegative, and tend to take up electrons far more readily than to give them up. Hence, in a pure state such bodies are non-conductors.

If, then, we consider a molecule, say, of carbide of silicon or of oxide of titanium, or other oxide or sulphide, it is quite possible that this complex molecule tends to give up electrons more freely at some points on its surface and to take them in more freely at others. It may be likened to a chamber or vessel with valves in it, some opening outwards and others opening inwards. Objects could only enter such a chamber at certain points and leave it at others. The same thing may be true of certain molecules; there may be places on them of easy ingress or way in for electrons, and places of most easy egress or way out. If a large number of such molecules were arranged irregularly, as in a non-crystalline mass, electrons could drift through them equally easily in all directions, because they would pass from molecule to molecule, taking advantage of those which were so placed as to afford ingress and egress in the direction in which they wanted to move. If, however, the same substance is crystallized, this presupposes a certain regularity of molecular arrangement, and it is possible that, in the case of some substances, this results in placing all the points of easy ingress on the molecules to face in one direction. Hence, such a structure would present the peculiarity that, if electrons tried to drift in one direction by passing from molecule to molecule, they would find the points of ingress and egress for electrons on all the molecules arranged in such a manner as to facilitate this drift. But then it would offer great obstruction to electronic motion in an opposite direction, and we should, therefore, be presented with the phenomenon of unilateral conductivity.

Closely connected with these crystal rectifiers is that form of oscillation valve devised by the author which depends on the unilateral conductivity of a mass of rarefied gas contained between an incandescent and a cold-conducting surface. In its simplest form this oscillation detector was first described in 1904 by the writer of this article (see British Patent Specification No. 24,850 of 1904), as follows:

A small incandescent lamp containing a carbon filament, which can be made brilliantly incandescent by an insulated battery, say, of 12 volts, has included in the bulb a metal cylinder, which surrounds, but does not touch, the filament. This metal cyl-

inder is carried upon an insulated support and connected with a third terminal sealed through the glass (see Fig. 2). If a circuit is formed connecting the negative terminal of

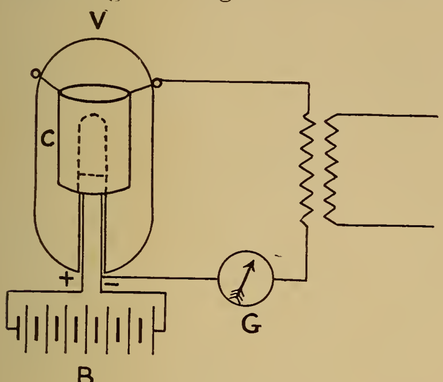



FIG. 2.—OSCILLATION VALVE

the lamp with the terminal of the insulated cylinder, then it is found that when the filament is incandescent an electromotive force inserted in this external circuit can send negative electricity from the incandescent filament to the cylinder, but not in the opposite direction. Hence, if a coil is inserted in this circuit in which oscillations are being produced, and also some instrument, such as a galvanometer, which is sensitive to continuous currents when oscillations are set up in the circuit, they will be rectified by the action of this oscillation valve, because only those currents will pass through the galvanometer which are equivalent to a movement of negative electricity in the bulb from the filament to the cylinder.

This oscillation valve was applied soon after its invention by the writer as a receiver in wireless telegraphy, and has since been used by Mr. Marconi as a long-distance receiver in transatlantic wireless telegraphy. For this purpose the receiving antenna is connected in series with one circuit of an oscillation transformer, the other circuit of which is closed by a condenser. To the terminals of this condenser is connected another circuit, consisting of the fine wire circuit of an ordinary induction coil, the thick wire circuit of which contains a telephone in series with it. An oscillation valve is inserted in the fine wire circuit of the last-named induction coil (see Fig. 3), and also a condenser is added for tuning purposes. When oscillations take place in the antenna they excite other syntonic oscillations in the closed condenser circuit. The alternating potential differences of the terminals of the condenser act through the valve, and with the result that the current through the fine-wire circuit of the induction coil is not an alternating current, but a current consisting of gushes of electricity in one direction only. If the waves falling on the antenna consist of intermittent damped trains of oscillations coming, say, at intervals of 50 or 100 per second or more, then the fine-wire circuit of the induction coil is traversed by brief electric currents at the same intervals of time.

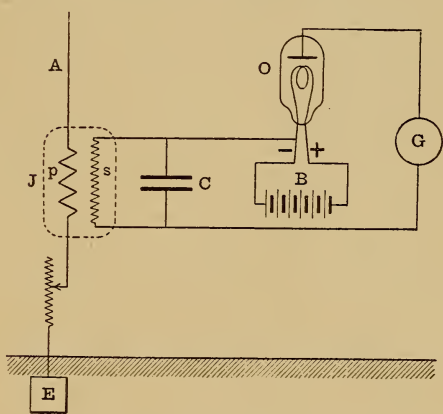



FIG. 3.—OSCILLATION VALVE DETECTOR

These are transformed down by the induction coil and act upon the telephone, producing an audible sound, which is cut up into signals of the Morse alphabet by properly intermitting the trains of waves of the transmitting station.

An arrangement of this kind has been used for long-distance wireless telegraphy very successfully.

The author has recently met with a filamentary material used for glow

lamps which gives results far superior to tantalum or carbon.

The principle on which the valve operates is, that in the case of an incandescent material, there is an ejection of electrons or negative ions from the surface; but this discharge of negative electricity is peculiarly large in the case of carbon. The carbon filament being a conductor, contains, as above described, free electrons, and when a current is passed through the filament the drift of electrons in one direction gives an increased further atomic ionization.

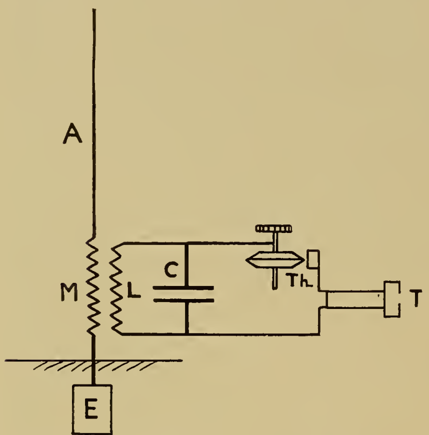



FIG. 4.—THERMO-ELECTRIC DETECTOR

The greatly increased kinetic energy of the electrons causes some of them, therefore, to be ejected out of the material beyond the range of attraction of the positively electrified ions which remain behind. If the filament is contained in a gas at atmospheric pressure, these electrons are not able to make their way to any sensible distance from the conductor; but if the filament is contained in a rarefied gas—in other words, in a high vacuum—the electrons are projected a considerable distance, and also ionize the residual gas. In this manner the space between the incandescent carbon filament and the metal cylinder in the above-described glow-lamp detector becomes populated with free electrons or negative ions. If, then, a potential difference is made between the filament and the cylinder, such that the cylinder is positively electrified and the filament negatively, the ions move from the filament to the cylinder, constituting an electric current; but reversed potential differences are not able to produce a current in the opposite direction, because the supply of electrons in the space becomes rapidly exhausted.

In the attempt to modify this invention of the author some patentees have introduced variations which are not an advantage. Thus, it has been proposed to employ tantalum instead of carbon as the incandescent material; but the researches of F. Deininger, as well as those of the author, have shown that incandescent carbon is superior in respect of electronic discharge to incandescent tantalum. In spite of the fact that this carbon oscillation valve was described by the writer in a patent specification and claimed as a receiver for wireless telegraphy, and also made known in scientific papers and in a published book prior to May, 1906, Mr. Lee de Forest subsequently made use of the same device, christening this replica of it an *audion,* under which name he has continued to use it as a receiver in radiotelegraphy and telephony.

Several recent types of oscillation detector have been devised depending upon thermoelectric action. If two small masses or substances lying far apart in the thermoelectric scale are pressed together, so that the surface of contact is very small, then the electric oscillations passed across the junction will create heat, and this action will create a thermoelectromotive force which can be made, in turn, to affect a telephone, and so produce sound. Thus a recent form of thermoelectric detector of this type has been described by the German Wireless Telegraph Company (see British Patent Specification No. 21,408, 1907). In this case a small copper disc with a sharp edge is thickly oxidized on the edge, and is made to press lightly against a small

block of soft metal, say tin or bismuth (see Fig. 4). This junction in series with a telephone is inserted as a shunt across the condenser in an oscillation circuit coupled to a wireless telegraph antenna (see Fig. 4). When electric waves strike upon the antenna they excite oscillations which are inductively transferred to the syntonic condenser circuit, and these, passing through the thermojunction, create a thermoelectromotive force which expends itself in producing a continuous current through the telephone. Each train of oscillations, therefore, makes a short current through the telephone, and, therefore, a sound; and if these trains of oscillation recur rapidly the telephone produces a continuous sound, which can be cut up into the signals of the Morse alphabet by properly controlling the trains of waves at the sending station.

A very similar detector has been described by L. W. Austin, in which tellurium is one of the elements of the thermo-couple. Tellurium and selenium lie at the opposite ends of the thermoelectric series; but, unfortunately, selenium has too little conductivity to be conveniently employed. The thermoelectric-couple, however, of tellurium and bismuth has been employed by the writer as a sensitive means of detecting and measuring oscillations. In this case the oscillations are passed through a very fine constantan wire contained in an exhausted tube (see Fig. 5), and the tellurium-bismuth thermojunction, constructed of very fine wire, is pressed against the centre of the constantan wire. The terminals of the thermojunction are connected to a galvanometer, and when oscillations are passed through the fine wire a current is indicated on this galvanometer.

The writer has found that, in a high vacuum, the current given by the thermoelectric couple is almost exactly proportional to the mean square value of the oscillations passing through the fine wire. Hence,

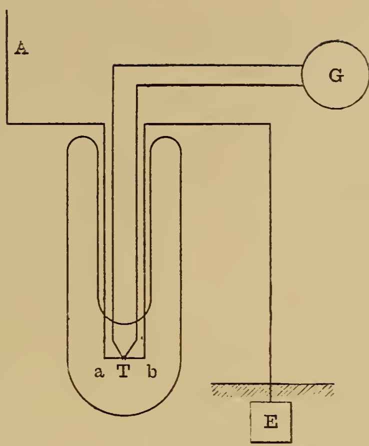


FIG. 5.—FLEMING THERMAL DETECTOR

such a detector is very useful for quantitative measurements.

Lastly, certain forms of self-restoring coherer have recently been invented, some of which are interesting.

Mr. L. H. Walter recently described to the Royal Society one interesting and novel form in which a tantalum point dips into mercury. This electric contact is improved when oscillations pass through it. The action is, in all probability, due to the fact that tantalum, like iron or steel and certain other metals, is not wetted by mercury. The passage of electric oscillations across the separating surface has, however, the effect of creating, whilst they last, a good electric contact. This improved contact ceases, however, when the oscillations stop. It is said that this detector has been used over a distance of 450 miles as a receiver in radiotelegraphy when coupled with a telephone and shunted cell, as in Fig. .

Space only permits of a brief reference to Poulsen's photographic receiver, which was recently exhibited in London. In this case, the feeble continuous current yielded by a thermoelectric oscillation detector is made to flow through a wire stretched in a very strong magnetic field. The current causes, therefore, a deflection of the wire, which is made to uncover a small opening through which a ray of light can

pass and fall upon a moving band or strip of photographic paper or film. The strip is, therefore, impressed with long or short marks, according to the time which the deflection lasts. These are arranged at will, in accordance with the dot and dash signals of the Morse alphabet, and a very high speed of transmission can be obtained, from 60 to 110 words a minute, with currents of 1 and 5 microamperes, respectively.

The advantages of obtaining a printed record of the message are unquestionable, and such a photographic method seems to present advantages not to be secured by any form of mechanical printer, owing to the entire absence of inertia in the mechanism.

# THE DISCOURAGEMENT OF PREVENTABLE FIRES

By James C. Bayles, Ph. D.

THE annual chart prepared under the direction of the New York Board of Underwriters, showing that through the past year the fires in Manhattan and the Bronx have averaged twenty-three a day, with a loss aggregating about ten millions of dollars, would fail of its purpose if regarded as merely interesting. Such statistics should at least be suggestive of plans of practical reform looking to the better safeguarding of property against injury or destruction from preventable fires. That they are not likely to do so may perhaps be explained by what has become our national habit of thought on this subject. We do not say Kismet, but if we did it would perhaps express our attitude. We have accepted the conclusion, quite unwarranted by the facts, that in some mysterious way fire insurance, by distributing fire losses, repays them, and that to keep "well insured" is wiser as a business policy than to take precautions against fires. Hence the reluctance with which the average policyholder gives even perfunctory compliance to the few and simple requirements which the companies carrying fire risks have found the courage to prescribe. The elementary economic truths, that insurance creates no wealth to replace that destroyed, and that as a system it penalizes prudence to make good the consequences of imprudence, carelessness and crime, should not be difficult of comprehension; but if comprehended it would perhaps be easier than it now appears to be effectually to discourage preventable fires.

Carried far enough, an analysis of fire statistics would show that only a small percentage of the fires result from causes which properly admit of classification as accidental. The number having their origin in causes which might easily have been foreseen and guarded against by such vigilance as it is proper to demand of those responsible for life and property, is probably ninety per cent. of the total. The remaining ten per cent. would include all that are really accidental, as due to unknown causes or to unusual effects of known causes, besides a good many impossible of thorough investigation. Most fires result from carelessness involving specific violations of laws or ordinances, and on the part of those responsible should be regarded as crimes or misdemeanors according to the gravity of their consequences. It is impossible to discover and effectually to discourage carelessness in such matters, and to enforce with adequate penalties impartially applied the laws and ordinances which are designed to make preventable fires infrequent and unimportant? The discussion of this subject is not wholly academic.

Let us suppose that when a fire occurred it was the immediate duty of a person properly qualified and vested with authority, to learn at once all that could be learned as to the cause or causes of it. This is assumed to be done in cases where incendiarism is suspected, but it is done so tardily and clumsily, and with so little intelligence, as to be of very little value. That, however, is another phase of the subject. We are not at the moment discussing incendiary fires, but those which result from preventable causes. If in the investigation of such fires violations of law or criminal negligence are found, it should be the duty

of the investigating officer to file an information against the owner, tenant and any one else involved, or all of them collectively. The next step would obviously be a summons for such persons to appear before the officer, commission or court vested with jurisdiction, and their examination. When the blame was finally focussed, and especially if a violation of the building or fire laws was established, or gross carelessness shown, why should not the person responsible meet the prescribed penalties of such violation, compensate the community for the service he made necessary and stand, prima facie, accountable in damages to those who have suffered injury? Such a procedure would not be unduly drastic, in view of the fact that each resident of a city is in a sense responsible not alone for his own life and property but for those of others. It costs a great deal to maintain a fire department in a high condition of efficiency. Even to respond to a false alarm is said to involve an expense averaging fifty dollars in wear and tear of apparatus, and not infrequently the cost is much greater. If a fire is to be dealt with the cost may rise to very large figures. Why should not the city recoup itself as far as it can from those who make this waste of public and private property necessary? More than all, why should not the carelessness which invites conflagration be discouraged by measures calculated to implant in the mind of the average citizen a wholesome respect for the law, if not for the rights of others?

One does not need to visit a city lying somewhere between Altruria and Utopia to find this same principle exemplified in a very practical and successful way. An American gentleman living with his family in Berlin was one morning awakened by the smell of smoke in his apartment, and found that a fire originating in a room overhead was eating its way down through the ceiling of his dining room. He dressed, went to the street and turned in an alarm, which in due course was responded to by the fire department. Such response is never what might be called precipitate in Germany, but is as prompt as circumstances seem to require. What is known in America as "red tape" seems to a foreigner very much in evidence in every German official proceeding, but I was never able to observe that it interfered with getting official work done in the best and most thorough way. The fire I am describing was extinguished with chemical apparatus without any water damage and without needless destruction of walls or furniture; and before the firemen left they had removed every trace of debris and scrubbed the floors of the rooms in which they had worked.

Meanwhile, a careful investigation was made by officers equipped with note books, not by asking questions of tenants or gossipping with servants, but from personal observation. Next morning the gentleman who had turned in the alarm was sent for and conducted before a fire marshal, or equivalent officer with inquisitorial powers. That he had important engagements elsewhere counted for nothing. Public business never waits on private convenience in Prussia. He was asked all sorts of questions, which he was able to answer satisfactorily. The fire was known to have originated in a coal which had dropped from a laundry stove in the attic and rolled upon an unprotected wooden floor. The tenant showed that the stove was an appointment of the building, provided by the landlord, and that it was neither his duty nor his privilege to change it. Then the landlord was called. He showed that he had but recently purchased the building, under the usual guaranty that all laws and ordinances had been complied with in construction and appointments; that he had neither set nor moved the stove in question, and that his attention had not been called to any conditions involving a fire risk. This was not considered quite satisfactory, and he was told to await further instructions. Then the builder, from whom the

landlord purchased, was called. He had to admit that he, as builder, was responsible for the setting of the stove as the police had found it, and that he had violated the law in neglecting to provide a suitable metallic hearth, of the required kind and dimensions, between it and the floor. For this he was held culpable. The assessment against him began with the estimated cost to the city of responding to the alarm and extinguishing the fire, included the damage to the furniture and property of tenants, and was rounded by an exemplary fine of 500 marks, as a reminder that laws are enacted for a purpose and carry substantial penalties for their violation. The damage to the building was not included in the assessment against the builder. It was held that while the owner had not committed the violation of law which caused the fire, he had been negligent in not discovering and correcting it, and for this reason he should pay for his own repairs and stand charged with knowledge of his duty in like cases. That he escaped a fine was deemed a cause for congratulation among his friends. Had he owned the building longer he would undoubtedly have had to pay a fine for neglect of duty in permitting a violation of law to exist on his premises.

Well, why not? Perhaps we cannot expect in American cities to do things as they are done in a capital of which the late Abram S. Hewitt once said: "If we could forget all we know about municipal government it would be no misfortune, since we might learn it much better in Berlin." But if we could even approximate the Berlin standard of intelligence and thoroughness in dealing with those responsible for preventable fires, we would cut down the annual fire loss to a very small percentage of what it is. In Berlin it pays those responsible in such matters to be careful to do nothing and neglect nothing for which, in the event of fire, they will be held responsible. Consequently, fires there are relatively infrequent and rarely serious. During some three years residence there I recall but one which attracted attention—an old market building, the destruction of which was generally regarded with satisfaction. In the United States we insure—and leave the rest to the fire department. The natural result is that fires are both numerous and costly. There are plenty of very good laws and ordinances, but they are of little practical value, since no one pays attention to them. They would enforce themselves if the penalties they prescribe were made great enough and were impartially exacted of those who incur them. Whether public opinion is ready for a movement in the direction of a reform so important and so obvious, is another question.

# THE RECLAMATION OF AN EMPIRE FROM THE SWAMPS

By George Ethelbert Walsh

FOR two decades the United States Government has been engaged in a stupendous engineering enterprise for the reclamation of the Western arid regions through irrigation, and in the various States millions of dollars have been invested in irrigating canals and storage reservoirs. This work has enlisted some of the best engineering talent of the country, and it has been the means of making "the desert veritably to blossom as the rose" and has converted land worth only a few dollars an acre into fertile fruit, grain and vegetable gardens, valued to-day at several hundred dollars per acre. The increased productivity of a vast region of arid land has added tens of millions of dollars to the annual crop valuation, returning in this way liberal returns on the huge investments.

The arid regions are located exclusively in the West and Southwest, but in the eastern part of the country there are great tracts of land unreclaimed which need only the opposite process to make them the richest and most fertile in the country. Along the whole length of the Atlantic coast, and near the borders of many of the great rivers and lakes, there are nearly a hundred million acres of drainable swamp land which has received more or less serious consideration from the government for the past half a century. As far back as 1850 the swamp land act was passed by Congress, under which various States have claimed more than 82,000,000 acres of land.

The United States Geological Survey has been making a careful study of this wet region for many years, and more than 400 topographic and hydrographic survey sheets have been made concerning the swamp areas. This survey of the wet lands has been the work of some fifteen years, and the final results of this great preliminary study are now likely to follow in the next dozen years. The reclamation of the swamp lands in the East by the National Government is considered a wise and fair policy in view of its extensive and profitable work in irrigating the western arid regions.

The Reclamation Service, which came into existence in 1902, had furnished the new Internal Waterways Commission with an abundance of data concerning the discharge and overflow of rivers and the possibility of storing water at certain points for preventing annual overflows and deluges. The Service is now in a position to begin the reclamation of a vast empire of fertile land at less actual cost than that of irrigating the arid land. The work of reclaiming much of this wet territory is a practical engineering feat of incalculable benefit to the country.

As an illustration of what can be accomplished in this direction, the office of experiment stations has in the last two years prepared practical working surveys and plans for draining the lands on the west side of the Red River in North Dakota, at an estimated cost of $1,000,000. The area to be drained comprises some 1,555,000 acres, and has a total length of 162 miles with an average width of 15 miles. To reclaim and put this wet land into commercial use, the cost thus averages less than a dollar per acre, and it is believed that the soil will be the richest in the State and capable of remarkable wheat production.

The engineering experts who have investigated swamp lands in the United States estimate that there is an amount of available wet soil that can be reclaimed equal to that of the arid regions, and that the cost will not only be much cheaper than irrigation, but much more accessible to the great mass of population. For the most part the great swamp belts are situated east of the Rocky Mountains, and there is hardly a State on the Atlantic border that has not a million or more acres of such wet soil within its territories. The possibilities of draining such great swamps cannot be entirely dissociated from the probable effect the engineering operations may have on adjoining land. For this reason the immense amount of preliminary study and survey by the Geological Survey has been considered essential for ultimate success. If the wet lands are drained, the effect upon higher land in reducing the level of the underground springs is a problem that cannot be ignored. Likewise the question of utilizing the drainage ditches for inland waterways is one that must enter into the problem.

The present tendency is to place the reclamation of the great swamp territories in the hands of the federal government by the various States, so that a comprehensive plan can be worked out without doing injury to any one portion of the country. Some of the extensive wet lands embrace parts of two or more States, and the attempt of one to drain the land might prove inimical to the best interests of another.

The largest swamp or wet land of any single State is situated in Florida, and embraces great tracts of low, watery soil which is of little value to-day for anything. There are upwards of 29,000 square miles of unreclaimed low lands in this single southern State. It is estimated that over four million acres of land in the Everglades could be reclaimed and converted into profitable fruit-growing territory. These great primeval solitudes have long attracted the notice of engineers, and various attempts have been made to drain them by lowering Lake Okeechobee. The Everglades consist of great tracts of saw-grass, cypress timber and almost inpenetrable marshes and lagoons. The soil of the Everglades is very rich. A private company which ditched and drained a section north of Lake Okeechobee has reclaimed land that produces the largest crop of tropical fruits of any land in Florida. The work of draining the Everglades is not insuperable from an engineering point of view, but it must embrace a comprehensive system that requires a large amount of capital and effective co-operation. Along the eastern border of the great swamp there is a ledge of rotten limestone which holds back the water. A drainage canal or series of canals cut through this ledge would lower the water level, and at the same time connect Lake Okeechobee with the ocean. This great inland sea is sufficiently deep to remain navigable over a greater portion even if the water level was lowered several feet. The surrounding swamp bordering the lake would then be drained and converted into profitable farming and fruit land.

Louisiana comes next to Florida in the extent of its swamp land, a large part of which can be reclaimed for farming purposes. There are about 15,000 square miles of lowlands in that State which are unprofitable to-day by reason of the water which spreads over it at certain seasons of the year. Some of the wet land has been utilized for rice growing, in which periodical flooding, under control, is not injurious; but the swamps proper are of no value to the State. Lagoons and sluggish streams thread their way through the swamps, forming irregular waterways for small boats at certain seasons. During the spring floods the water sweeps over much of the land at a higher altitude, and for weeks many farms are partially flooded and destroyed. The drainage of this low swampy land of Louisiana presents more difficult engineering problems than that of the

Everglades of Florida. The periodical overflow of the Mississippi becomes a factor in the situation, and to make the former successful the control of the "Father of Waters" is a preliminary essential. But the storage of water of overflowing rivers for use in the dry season is one of the problems which the Inland Waterways Commission has now under consideration, and with the solution of this vexing question accomplished the drainage of the low swampy lands along its border would follow easily.

Arkansas has 9,000 square miles of swamp land of the richest imaginable soil, which proper drainage would convert into good farming land. Mississippi has an equal area of wet land for reclamation, and in the northwest, bordering on the Great Lakes, Michigan and Minnesota follow with 7,500 and 6,000 square miles respectively. In the two latter States the low lands are used to some extent for cranberry cultivation, and this employment of them has added a considerable sum to the crop output of the land. Wisconsin has about 4,500 square miles of swamp land; Maine, 4,000; Georgia, 3,750; Illinois, 3,500; Texas, 3,500; North Carolina, 3,750; Missouri, 3,000; South Carolina, 2,750; New York, 2,500; Virginia, 1,600; Tennesee, 1,250; Ohio, 1,250; Indiana, 1,250; Alabama, 1,750; New Jersey, 900; New Hampshire, 600; Maryland and Massachusetts, 500 each; Vermont, Nebraska and Iowa, 400 each; North Dakota, 375; Pennsylvania, 300; Kentucky, 350; Kansas, 250; Connecticut, 200; Delaware, 50; Rhode Island, 30, and the western S tates about 10,000. A total of nearly 130,000 square miles of wet swamp land has thus been surveyed and mapped out by the Geological Survey. While all of this land may not be reclaimable, it is the opinion of the experts that the greater part of it can be drained and converted into useful farm soil.

A study of this list of swamps will show that millions of acres of rich soil could be reclaimed within short distances of areas of densest population. From this soil could be raised crops sufficient to support a population several times greater than all now inhabiting the eastern seaboard States. Much of the land borders on the Atlantic coast, so that the crops could be transported in boats to the great seaport towns. In draining many of the largest swamps, navigable ditches would be cut through the land so that boats could pass through the rich farming region to facilitate transportation of products. The engineering work would have to consider the question of disposing of a great surplus of water during the rainy seasons, and this in itself constitutes a difficult piece of calculation. The new river channels in some instances would be called upon to accommodate two or three times as much water as in ordinary seasons, and unless they could adequately drain off this flood the adjoining land would be periodically inundated. In some cases the plans of the Geological Survey include immense storage reservoirs through the swamps which would take care of any surplus of water and hold it until the freshets subsided.

Many serious attempts have been made in the past by private and State associations to reclaim land under water by extensive drainage systems, and all told millions of very rich soil have thus been brought into a suitable condition for cultivation. In Florida alone private drainage companies have reclaimed several million acres of land that are to-day producing abundant crops of fruits. The greatest of these enterprises was undertaken in 1881 by the Atlantic and Gulf Coast Canal and Okeechobee Land Company, which proposed the difficult plan of lowering Lake Okeechobee, which is 22 feet above the ocean. In order to make the scheme practical it was necessary to lower the lake at least six or eight feet. Although the Everglades are far from being properly drained to-day, the land companies have reclaimed so far between two and three million acres

by means of their series of ditches, canals and lakes. The complete draining of this vast swampy area, however, is too great an undertaking for a private company, and eventually the federal government will probably finish the project. The draining of the Everglades will be the means of adding millions of square miles of the richest semi-tropical soil in the world to cultivation, and the products from this new empire will be sufficient to supply the northern markets with such fruits as oranges, pineapples, lemons and grape-fruit for years to come.

The project of draining the great Dismal Swamp of Virginia is another interesting and historical enterprise which offers some interesting data to the drainage engineers of to-day. This vast swamp is some twenty feet above high tide-water mark, but as it is situated practically on a hillside which slopes gradually toward the sea, an artificial outlet for its water is not difficult. Parts of this swamp have been drained by private companies in the past, and a canal through one portion of it forms a connecting link in the inside all-water route from New York to Florida. This canal was begun in the days of Washington, and was one of the first canal projects contemplated by the colonists. It was first started by lumbermen, who dug a waterway through the swamp in their search for juniper trees. With a ditch thus cut through the heart of the swamp, the authorities surveyed a canal that would lessen the cost of transportation; but the canal, like many others of those early days, was later abandoned.

The draining of the Dismal Swamp would add to the State of Virginia many millions of acres of rich soil that could be kept in an excellent state of cultivation through irrigation in dry seasons. In draining the wet lands, the question of utilizing the water in the drainage ditches for irrigation purposes should not be overlooked. Frequently in the warm seasons parts of the swamps are to-day dry, and to carry the water off entirely would leave the reclaimed soil in as bad a condition as before. The comprehensive plans of drainage perfected by the government, therefore, involve future irrigation as well as drainage. The waters would be carried off in wet seasons and stored in sufficient quantities for irrigation in dry summers.

Of the 130,000 square miles of wet lands in the United States, it is estimated by the drainage experts of the government that fully 80,000,000 acres can be profitably reclaimed. Furthermore, the opinion, based upon careful surveys, that it will not cost more than $6 per acre on an average to reclaim this vast empire of swampy soil is a good guarantee that the scheme will be profitable. Much of the land thus drained would easily be worth several hundred dollars per acre in view of its proximity to large centers of population. The present value of the wet lands is practically nothing. They yield no crops and can hardly be called of any value as timber land. In parts of the Dismal Swamp and the Everglades, a certain amount of good timber grows, but the difficulty of reaching and logging this timber makes the value somewhat uncertain. Even for hunting purposes the swamps do not present any particular value. Game of a certain semi-aquatic sort lives in the swampy recesses and breeds there, but only pot-hunters and feather-hunters can reach it. They offer neither hunting for the sportman or restful camping for the vacationists. They are for the most part vast dismal regions shunned by man and wild creatures.

The wet lands of most of these swamps have been accumulating fertility through countless ages. The decaying vegetable life has spread over the wet surface layers of rich fertilizer that could furnish plant food for many decades. If once reclaimed they would prove the richest farming land in the country. In the great wet-land belts of many of the States are included natural peat bogs, which are to-day viewed by scientists with a

good deal of interest. These extensive peat bogs may yet become important sources of our fuel. Experimental operations are now being conducted by different private companies for utilizing this peat in a commercial way. While no great success has yet attended these experiments there is a consensus of opinion that in the future the peat bogs will prove valuable assets to many of the States far removed from coal mines.

The government is practically committed to this great scheme of reclaiming the wet lands of the country, and from them will in time be produced some two million fertile farms of forty acres each. Thus there will be new farming territory added to the country, and mostly in the more populous eastern field, sufficient to furnish homes of a prosperous character for some ten million inhabitants. The effect of these prosperous farms in the cost of living would certainly prove of great economic importance. The cost of draining such a vast empire is tentatively placed by the government experts at $480,000,000, but if this should give to the reclaimable land an average valuation of $100 per acre the immediate returns would represent something like $8,000,000,000. As an economic and profitable investment the scheme would prove a most satisfactory one.

Another feature of this great economic move of the government is the probable effect the drainage of the swamps would have upon the health of the people. Scientists agree that these vast swamps and morasses are fertile breeding places for mosquitoes and flies, as well as malaria and many kindred fevers. It is impossible to exterminate the mosquito until swamp lands are practically drained and converted into tillable soil. The water settled in them is for the most part sluggish and stagnant, in which the larvae of the insects thrive. The drainage of the low lands would deprive the insects of their last place of refuge and would convert unhealthful regions into good, wholesome places for man to live.

The engineering problems of this great scheme would furnish experience for a large class of young men who have been studying the drainage and irrigation questions of this country. In its irrigation enterprises in the West the United States Government has trained a considerable body of good engineers in a service which must continue to grow in importance in a land of this size and topography. These engineers have shown an amount of enthusiasm and persistency in their work which have created for them a national reputation. Some few have left the government's service to take high positions in private engineering companies, and their experience and working data are constantly being sought by engineers and capitalists interested in reclamation and irrigation schemes. The effect of the national government in building great irrigation works in the West has been to encourage private individuals to work along the same line. Hundreds of private companies are to-day establishing small irrigation plants, using the data and experience furnished by the government's engineers.

In a similar way it is expected that the reclamation service will act as a stimulus to private individuals to enter more largely into drainage schemes. A few practical demonstrations in draining the larger swamps by the government would be the means of inducing others to follow the example on a smaller scale. There are vast meadow districts near many of the large cities which are to-day practically worthless land. Some day in the future their reclamation will add untold millions to those enterprising individuals who can command the capital and brains to drain them. This work, although a little different from that of reclaiming the swamps for farming purposes, is nevertheless sufficiently identical in engineering practice to make it of interest in the consideration of the wider subject.

# Current Topics

ONE of the interesting features in the development of mechanical science appears in the introduction of what would formerly have been called laboratory methods in daily shop practice. The old idea was that scientific methods were almost entirely theoretical in their nature and hence unworthy of the attention of the practical man. Pig iron was graded by fracture, strength of materials by rule-of thumb methods, hardness by the touch of the file, and, in general, information concerning the materials used in the shop was of a very indefinite and unreliable kind.

That some of the old, crude methods still obtain cannot be denied, but the demand for precise and accurate results has led to the development of laboratory methods until they have become daily operations conducted by operative mechanics in the shop, the foundry, and the mill.

The introduction of the chemist into the iron works resulted in the enormous development of output in Great Britain, Germany, and the United States, and the chemist is now followed by the metallographist, so that the composition and the physical constitution of the product have become definite and quantitative matters. In like manner the use of instruments of precise measurement has been extended from the physical laboratory to the tool room, and from the tool room to the workshop bench, so that the ten-thousandth of an inch has a very practical meaning in the shop, and the allowance for a running, driving or shrinking fit has become a matter for accurate determination, and not a question for the intuition of the individual mechanic.

The tensile strength of materials has been a subject for investigation for many years, but it is only recently that some other properties of iron, steel and alloys have been satisfactorily determined. Thus, the important matter of the measurement of hardness of metals did not receive systematic scientific attention until Professor Brinell, in Sweden, began his investigations, which culminated in the presentation of the so-called "ball" test, in a paper before the Iron and Steel Institute by Mr. Axel Wahlberg, in 1901. However this method may have been criticised, it certainly made a definite beginning in the matter, and offered a basis for the comparison of the hardness of various metals upon some sort of a quantitative basis. Modifications of the Brinell method by Benedick, and by Sandberg, served to show that the system possessed a real value, while the investigations of Dillner, in Sweden, and of Stead and Greville-Jones in England, confirmed this view.

Very recently there have been developed two other methods, both of which, together with the Brinell ball system, are fully discussed in the

paper of Mr. Springer, elsewhere in this issue, and there is every reason to believe that the practical application of either the magnetic method of Hughes and Kryloff, or the scleroscope of Mr. Shore, will place in the hands of the constructive engineer information which has been greatly desired and almost entirely inaccessible heretofore.

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At the present time there is an especial demand for accurate information about the properties of materials of construction because of the necessity for the reduction of the weight and dimensions of many mechanical parts to a minimum. The designer who is endeavoring to produce a motor, for example, which shall be available for aeroplane service, because of its combined lightness and power, cannot remain long contented with the assumption of an arbitrary "factor of safety." He demands precise knowledge not only of the tensile strength, but also of the wearing properties; he must know just what stresses he may apply, and just how near the elastic limit, or the limit of wear, he is approaching; he has to know, and he dare not guess.

The metallurgist is daily producing new alloys, and having produced those which meet the demand, he must be able to maintain the standard of the product.. Unsubstantiated claims will no do; precise and convincing facts must be furnished, and for this purpose the methods of the chemical and physical laboratory must be carried into the workshop, and once there, they remain and progress.

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An interesting demonstration of the continual development of the internal-combustion motor appears in its entrance into what may fairly be considered one of the most difficult fields for the prime mover, the operation of textile machinery. The builder of steam engines for this exacting service has felt rather safe in the belief that this market would remain in his hands for a long time to come, and those who remember the jerky and varying speed of the early gas engines, operating under what was very properly called "hit or miss" control, can scarcely believe that the speed regulation of the combustion motor has been so improved that it has been successfully applied to the driving of the machinery of the cotton mills of Lancashire.

That such is the fact must now be admitted, and there thus appears a wide field for the gas-engine builder, especially in Great Britain. With the speed regulation equalled, if not surpassed, and with the fuel cost cut in two, the steam engine will find the gas engine a vigorous competitor in one of the greatest industrial fields of the country, a field which should yield a valuable harvest to the energetic cultivator.

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We live in an age unequalled in mechanical progress in the world's history, yet it is beyond question that the ancient civilizations of Babylon and Egypt had methods and appliances which we have yet to rediscover. Although it is not probable that our present civilization is likely to be swept away, leaving no trace of its development, it would be a fitting heritage to posterity if we left, in a National Museum of Manufactures, a representative type of each machine and appliance, showing its development from its earliest inception, in stages of, say, every ten years, up to the present. When machine tools ten years old are considered obsolete, and electric power stations six years in use are considered out of date, it is quite possible to imagine our successors two decades hence reinventing and designing things we have discarded.

The old man's saying, "I have probably forgot more than you have learned," may be as true of a nation as of an individual. The history of machine tools bears testimony to the fact, that in seeking to make improvements we have often discarded a machine, right in principle, but not well thought out in detail, for a machine wrong in

principle, but well made and handy to operate. If we could study our subject by the Darwinian method we would probably produce a better article with less experimental work and fewer reactions. Again, one branch of engineering may with advantage borrow ideas from another; as an example, the time cams on automatics have their origin in printing machines.

The marine engine and the locomotive show the best examples of engineering practice for heavy continuous duty, while the agricultural implement shows marvels of cheapness, together with ingenuity in design.

The modern bicycle again shows a maximum of strength for a minimum weight.

The discovery and recognition of genius should be one of the chief aims of a civilized state, and it is only in so far as a country adopts this ideal does it progress in arts and manufactures. While the literary man and the orator has access to a large public opinion, and the students in our schools and universities have opportunities for distinction, the inventor, who is at least equally a son of genius, has no recognized tribunal where the product of his brain can be inspected and weighed in the balance, to discover the utility, if any, and to mark the advance he has made. He is very often the beggar seeking some manufacturer who may condescend to examine the precious child of his thoughts and long-cherished ideas. Surely a nation whose existence depends largely on its manufactures, and who seeks to lead the van of progress, could afford to spend a few thousands a year to foster the spirit of inventions and discovery.

If a number of prizes were open each year for the best practical machine in, say, two or three departments of engineering, and the value of the prize to approximately cover the cost of the machine itself, it would widen the opportunities of the best brains of the nation and give the chance necessary for comparison and recognition. The institution we propose would also help inventors by having a reference in *fact* of each machine and appliance. The records of the Patent Office testify that many men have puzzled their brains reinventing mechanisms that have been in use for years, to know what has already been accomplished is a great gain to all who seek to make improvements.

The object of all commercial ventures is to make money, but although this is not the direct object of the institution we propose, we think it would materially help manufacturers by having a permanent exhibition of the nation's best products. How difficult it is to get to know the various types of one machine, and to study them comparatively, yet how much more difficult it is for foreign people visiting us to know about such a machine and where it is made. We would suggest competitions on the lines of the Royal Agricultural Society, and together with a prize would be the permanent exhibition of the prize winner.

We have only set forth some of the most prominent claims for consideration, but there are many others which will appeal to readers. As an educational institution it would be invaluable, and if near an engineering college could be used with great advantage by the students.

No doubt the difficulty of commencing such an institution would be very great, but if some of our millionaire engineers and manufacturers would be interested they could erect a lasting monument to their fame and worthy of a century of engineering development and progress.

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IT is interesting to note that the Liverpool Dock Board are about to construct a new dock with a lock entrance 870 feet long, 130 feet wide, and with a sill 30 feet below Old Dock Sill or 20 feet below low water spring tides. This lock is therefore 90 feet longer than the biggest ships afloat and 42 feet wider, so that it has to some extent discounted the future. It will have a water depth of 40 feet at high water neap tide, and of 50 feet at ordinary spring tide. There

will be two new docks with a half-tide connecting lock, and quays, 1,215, 1,235, 1,265 and 1,480 feet long. The new docks will connect with some of the existing older docks by means of a lock 645 feet long and 90 feet wide. Evidently Liverpool is of no mind to be ousted by the port of Southampton, and indeed Southampton cannot continue to rely entirely on its natural advantages, for even such a ship as the *Adriatic,* of only 25,000 tons, cannot apparently be brought in by the western end of the Solent at all states of the tide, but has to run south of the island and come in at the Spithead end, much to the upsetting of the topography of passengers who have failed to note the turn and are hazy as to the position of the sun.

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IT seems strange to read of the lining of oil wells in Baku with riveted-iron casing, and no surprise need be felt at the fact that they leak and allow water to enter the well. How can a riveted and thin sheet pipe do otherwise than spring open between the rivets if any attempt is made to drive it? Modern artesian drive pipe is the proper pipe to use. As made by Jas. Russell & Sons, this pipe is thick lap-welded steel, faced off true at the ends and screwed to butt inside a thin special steel socket. Such pipes alone will stand real hard driving. Flush-jointed pipes drive perhaps more easily in the absence of the projecting sockets, but they have to be cut very thin at the abutting screwed end, and often one of the half faces butts first and is crippled before the other takes its share and the joint is telescoped. American as well as English practice favours the socketed pipe for heavy driving. Tube makers should look for business in Baku, where now it seems much of the oil-well lining is coming from Germany.

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ALL cheap merchant goods suffer in process of years from a species of degeneration. We refer, of course, to those cheap lines of articles that are made by the thousand, are rarely to be seen in the outside world, yet go off day after day, fifty at a time, and never come back. When these things start in life there is a drawing and there is a pattern, and in time this pattern is worn out. Possibly the last job it is used for is to mould a final article which is filed and stoned smooth and becomes an iron pattern. It has none of the sharpness of the original wooden pattern and has lost its corners and so on, and perhaps in turn it also wears out and serves its last turn as a pattern, whence is cast an even more degenerate pattern. And thus, stey by step, a process of degradation goes on and the article of constant sale takes on the well-known appearance that is associated with the cheap merchant article. The degenerate article costs as much to make as though it were still good. The lesson to be learned is, of course, that the first pattern should only be used as a pattern from which to cast working patterns.

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IT does not seem to have been generally known that the Manchester Ship Canal, constructed for a depth of 26 feet, has now been dredged to a depth of 28 feet. It has required four years to complete the work, during which much rock has been removed, for the canal in parts is cut through solid rock, fortunately a not very hard sandstone. The largest merchant steamers can now proceed to Manchester without parting with cargo, and steamers can be loaded and bunkered complete before leaving Manchester. The depth of 26 feet was perhaps fixed on for financial reasons, but the same reasons in a different direction, i. e., a revenue-earning sense, have demanded the additional two feet of depth. The modern cargo steamer has grown, and no canal that will not float it can expect to gain a full share of the traffic that would otherwise come into it. Yet in spite of the continual growth of the trade of the Manchester Ship Canal, Liverpool finds it necessary to construct new docks.

By the end of this year the White Star Line will have at sea the *Laurentic,* a vessel of 14,000 tons, propelled by a combination of reciprocating engines and low-pressure turbines. So far as present appearances tell there appears to be a future for this combination. Owing, perhaps, partly to the policy of reticence of facts and partly to actual facts, the steam turbine has lost a bit of its suddenly-acquired glory. When blades are short the clearance may mean a good deal of leakage, and this may account for heavy coal consumption. But there seems little doubt as to the efficiency of the comparatively cool low pressure or exhaust turbine, and the proposed combination will be watched with interest. Meantime the Scotch-built *Lusitania* appears to be mending her performances every voyage, while the English-built *Mauretania* continues to excel her, and to do so while using only three of her four propellers. There is always something inexplicable about propellers. Builders pile in propellers and multiply blades. The marine lobster casts off a claw here and there and goes better for the loss. Did not the early *Comet* show the way by casting off the bulk of her first propeller with great advantage? But engineers still are prone to doubt the capacity of the paltry looking fan and do not possess perhaps the courage of their convictions.

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IN Switzerland there is a National Federal laboratory for fuel analysis, which in one year, the first of its existence, analysed and tested over 3,000 samples of fuel, coal and briquettes. Fuel here is tested chemically to determine its constituents, physically for Sp. gr. volatile matter, moisture, ash, and mechanically for cohesion in the case of briquettes.

The laboratory is very fully equipped with apparatus and with appliances for rendering the results reliable and to facilitate accuracy. Then the temperature is regulated all the year round by special heating, and cooling is to be applied also for the same purpose. There are drying ovens, balances, grinding machinery, and, in short, everything necessary. The laboratory cost about £2,000 to set to work in an old building, which was suitably modified. For a small country like Switzerland, with only three million people, the import of coal to the value of £3,000,000 is a large item and this laboratory has been inaugurated so that the subject of fuel can be put upon a sound basis, and in order that the purchase of fuel shall be conducted upon sound principles.

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ACCORDING to Dr. Grossman boiler plate will not suffer from corrosion if magnesian waters or carbonate of lime be present. But if an inefficient softening process has first been carried out corrosion is intensified. As regards sea water, carbonate of lime will not prevent corrosion, but slaked lime will do so at such temperatures as are used for its distillation. We believe that marine engineers have long ago found the value of lime as an anti-corrosive. They use it to obtain an eggshell scale.

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MR. MITCHELL'S paper on the Rateau system of exhaust steam turbines read before the Cleveland Institution of Engineers was, of course, a piece of special pleading for the particular system he is interested in. It was an excellent paper and no fault is to be found with it. But it ought not to be taken, as we believe it is being taken, even by some who should know better, as an unique instance of the use of exhaust steam. It is, of course, nothing of the sort. Plenty of engines which run under non-condensing conditions could just as easily be made to exhaust into a low-pressure container, whence a condensing engine should draw its steam. There is perhaps some little novelty in the use of steam continuously from engines which, like winding engines, only run intermittently, but the idea of the low-pressure container is not new. To improve it by the addition within the

container of water to serve as an accumulator of heat, to act as an absorber or as a deliverer of steam by means of changing pressure, is merely an extension of the idea which underlies the use of the Lancashire and similar boilers, to wit, great water capacity. All boilers with large water capacity will give up a lot of steam for a small drop in pressure, but they are, of course, slow in getting up pressure again. The fire-heated boiler acquires fresh heat from the fire by means of a circulation of the water. In the Rateau accumulator the exhaust steam must be dispersed through the body of the water by small outlets from numerous pipes, for water will not readily absorb heat from steam above it, unless the water is moving and agitated. An exhaust-heat accumulator could very well be worked like a sprinkling feed heater by means of a rotary pump to shower water constantly through a steam space above the water, the water being drawn continually from the bottom of the vessel. The giving out of the stored heat is a simple matter and follows promptly on withdrawal of steam and reduction of pressure.

The turbine lends itself conveniently as the machine to use low-pressure steam. It is the logical outcome in practice of the kinetic theory of gases just as is the exhaust injector for boiler feeding. But a good vacuum seems to be more essential to success than it is with a reciprocating engine. Anyone who has an old engine can run it condensing, just in the same way as the exhaust-steam turbine is run out of the exhaust accumulator. Over thirty years ago the writer of this note ran a beam engine for half an hour from a Lancashire boiler which had no fire under it and had a hole in its furnace, the fusible plug having blown out. The water helped by the hot brickwork gave off vapour enough to condense, and the engine would have run much longer had a dab of clay been put into the opening of the melted-out plug.

IN the cruise of the *Indomitable* there has been demonstrated the existence of what may well be termed a new type of warship, the battleship and the cruiser combined. The *Dreadnought* has been considered as the most heavily armed battleship in the world, while the Cunard turbine-liners hold the record for sea speed, but in the run from Quebec to Cowes, or rather from South Point, Belle Isle, to Land's End, the *Indomitable* made an average speed of nearly 25 knots, or, more precisely, 24.8 knots, with a four-hour speed of 26.4 knots, and an average speed between Belle Isle and Fastnet of 25.13 knots. These are speeds exceeding those of the swiftest cruisers and closely aproaching those of the *Lusitania* and the *Mauretania,* and yet, be it remembered, they were made by a warship with a seven-inch armour belt, carrying eight twelve-inch guns in four turrets protected with ten-inch armour.

Apart from this remarkable speed-record, there are some features about the *Indomitable* which render the vessel unique in the annals of marine and naval engineering. The hull was laid down at Fairfield in the Spring of 1906, and in two years she was ready for her trial trip. Her contract speed was 25 knots, and she has exceeded it, not only on her trials, but for days at a time on the high seas.

That such a vessel costs fifty per cent. more than a battleship of the ordinary type cannot be considered as an objection, since the offensive power is far greater in proportion than the increase of cost, the armament alone being practically double, while the cost of maintenance is estimated as about half; since it would require twice the number of ordinary battleships to carry the same number of heavy guns.

Thus the engineer has again rendered existing naval equipment largely obsolete by the rapid improvement

in fighting machinery; and, let us hope, contributed once more to the maintenance of the peace of the world by providing such effective policing of the seas as will deter the most belligerent from the appeal to arms.

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THE recent demonstrations of Mr. Wright in France with his aeroplane have naturally attracted much attention, and the work of the Wright brothers is considered by many engineers as having done very much in advancing the solution of the problem of mechanical flight. Apart from the improvements which these indefatigable experimenters have made in the machine which represent their latest work, they have brought out an important element in the matter to which, we believe, sufficient attention has not been given.

In nearly all cases it is the design and construction of the machine which have been made the principal objects of effort, and it has been assumed that when the form and control of the planes have been determined, and the power, reliability and lightness of the motor assured, the rest would be easy. It must not be forgotten, however, that there are many accomplishments concerning which practically everything is known, and which yet require long periods of time for their mastery. The Wright brothers have been practicing with gliding flight for years, taking up the work where it was left by Lilienthal, and familiarizing themselves with the art of balancing, and with all the personal elements which are absolutely essential to success in the air, before they so much as attempted to make and operate a power-propelled machine. The conquest of the air must be made by gradual personal experience, just as the child learns to walk, to swim, to ride the bicycle; and to attempt to fly without such a training is to invite disaster, even with the perfect machine, should such be made.

The violin is a simple instrument, and many able performers have endeavored to write treatises explaining how it is played, but the man who attempts to use it finds that arduous practice for months and years is necessary before success is possible. In like manner must the performer on the aeroplane accept the fact that he has to learn the art, and that it cannot be acquired in a day, but demands laborious and persistent effort, until its accomplishment becomes a combination of motions as automatic and instinctive as those involved in our present everyday movements.

# J. STEPHEN JEANS

A BIOGRAPHICAL SKETCH

IN the iron and steel trades there is no better-known name than that of Mr. J. Stephen Jeans, who since 1877 and until quite recently held the post of secretary to the British Iron Trade Association.

Mr. Jeans was born at Elgin, and started life as a journalist. At the early age of 24 he became editor of the Glasgow "Evening Star," one of the first halfpenny newspapers.

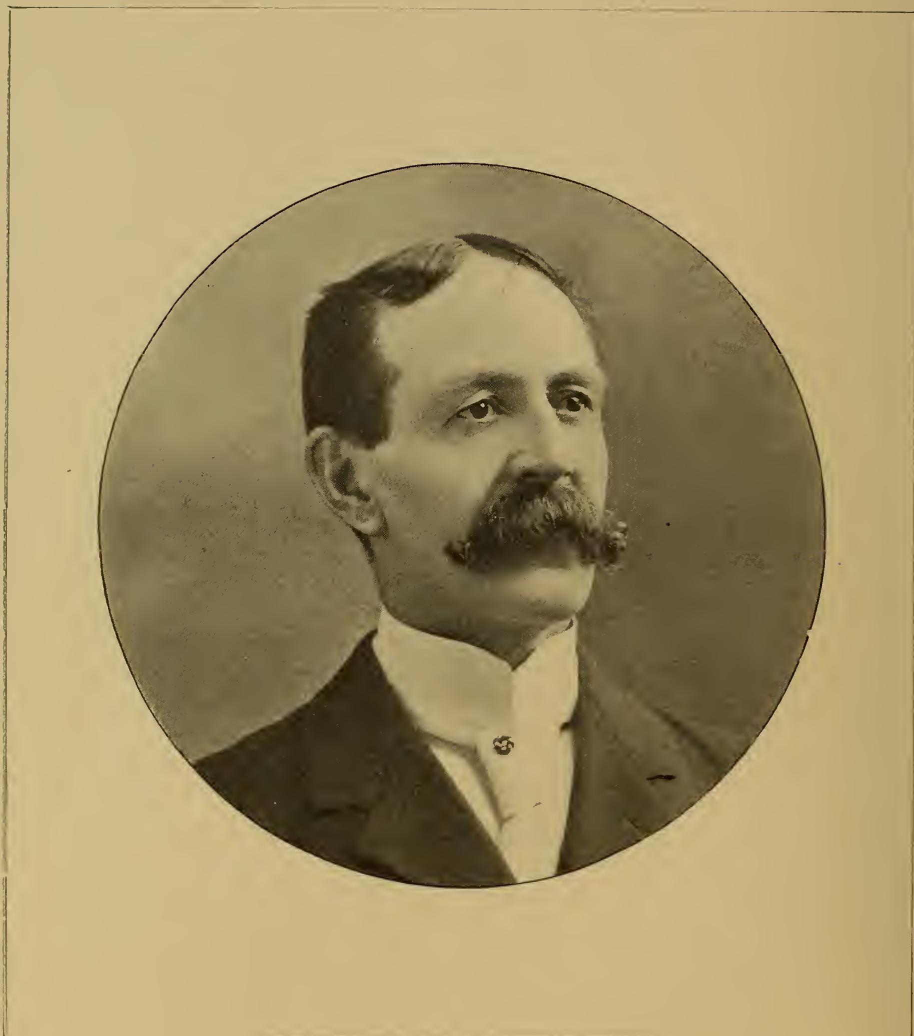
After some time, Mr. Jeans left Glasgow and was approached by Mr. Henry King Sparke, a well-known North of England colliery owner, to undertake the editorship of the Darlington and Stockton "Times." His residence there brought him into contact with a number of men connected with the iron and steel trades of Stockton and Middlesbrough, and when the post of secretary to the Iron and Steel Institute became vacant in 1878 Mr. Jeans was urged by the late Sir David Dale, Mr. E. Windsor Richards and the late Mr. Edward Williams to apply for the position, which he did, and was unanimously elected by a committee, of which the late Duke of Devonshire was chairman. At the same time, Mr. Jeans took up the secretaryship of the British Iron Trade Association.

Mr. Jeans is now editor and chief proprietor of the "Iron and Coal Trades Review," and has written various papers on the iron and steel trades, as well as numerous works of a politico-economic character, such as "England's Supremacy," 1885; "Railway Problems," 1886; "Waterways and Water Transport," 1890; "Pools and Corners," 1893; "Industrial Arbitration and Conciliation," 1894, and an important work on steel, the first of its kind, in 1880.

Mr. Jeans has organized and carried out various meetings of the Iron and Steel Institute, and has organized various commissions. He prepared and conducted the case of the British iron trade before the commission appointed in 1888 to inquire into the railway and canal traffic act, and has given evidence before the Royal Commission on Coal Supplies, the Royal Commission on Food Supplies and Raw Materials in Time of War, and before various select and important committees.

Owing to ill health, Mr. Jeans recently resigned his post of secretary to the British Iron Trade Association, which he has held since 1887, and we understand that the members are presenting him with a testimonial.

Mr. Jeans is well known in the United States, where he has many friends and where the importance of the work which he done for the development of the industry of iron and steel, both by his writings and by his activity in the Iron and Steel Institute, is fully appreciated.



WILLIAM R. RONEY, M. Am. Soc. M. E.

INVENTOR OF THE RONEY MECHANICAL STOKER

SEE PAGE 576

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# THE WORLD'S TIN SUPPLY

By T. Good

SOME very ominous warnings have been uttered recently concerning our future supplies of tin. We have been told that while the world's demand for tin steadily increases, there is no sign of any material increase in the supplies of this valuable metal. Indeed, we are being gravely assured on high authority that there is unmistakable evidence of early exhaustion of the world's best deposits, and with failure, so far, of the attempts to find a suitable substitute for tin, the day is not far distant when this commodity will take rank as a very precious metal, and will command a price quite prohibitive so far as common industrial purposes are concerned. In these circumstances it will not be superfluous to inquire what grounds there are for alarm on the score of future tin supplies.

In a report recently issued by the Frankfort *Metallgesellschaft* it is stated that in the Straits Settlements, from which more than half the world's tin comes, "the alluvial deposits now in course of exploitation are becoming poorer and are gradually approaching exhaustion. . . . Cost of production is increasing . . . and the transition from open to deep-level workings will probably every year make strong advances." From other sources we get similar pessimistic accounts. These gloomy predictions of an early tin famine remind us of the equally dark and dismal prognostications about an approaching coal famine, and an approaching iron famine, which have been dinned in our ears so persistently in recent years. We have no desire or intention to discredit the reports of the experts regarding the conditions of those mines, or deposits, with which their reports are concerned. We are aware of the growing costs of operation, and of the gradual depletion of many of the best known deposits; but we do question—and question seriously—the pessimistic conclusions which are generally based upon these reports. The evidence may be undeniable, so far as it goes, but it is not always wise to base broad and general conclusions upon the evidence relating to local and individual cases. Judgment ought not to be passed hastily upon any evidence regardless of the counter-evidence available, especially in the matter of mineral deposits.

People who are constantly predicting tin famines, and coal and iron and copper famines, fail to make due allowance for possible future discoveries of these minerals, and for the possibilities of improved methods

of mining and treating. As we have pointed out in these pages when dealing with iron ore supplies,* we have not yet done more than tap the mere crust of the earth, and only some portions even of that. Besides, we refuse to believe that science has said its last word either in mining or metallurgy. Taking a broad view of the matter, and allowing for the possibilities of future discoveries of minerals, and the possibilities of improvements in mining, treating, and transportation, we can see no justification for the prevalent and growing alarm. We venture to go further and say, as we said in the case of iron ore, that our already ascertained knowledge is quite sufficient to dispel anxiety in our day, while future generations, with an ever-growing development of scientific knowledge, and of power over Nature, may very safely be left to work out their own industrial salvation.

It is quite true that in many parts of the North American Continent—in Alaska, Mexico, and the United States—a great deal of money and labour have been spent in prospecting for workable tin-bearing ores, but with very little success. But traces, at least, of the mineral have been found, and it is just possible that more than traces may be found, for the whole of the Continent has not been sampled yet.

In South America, however, the prospects are distinctly good. In many parts of the Andes tin has been found in such quantities as to inspire the hope, if not the belief, that that vast range of mountains contains an almost inexhaustible supply of tin-bearing ores. In the Bolivian and neighbouring Andes, excellent deposits exist. Certain difficulties are met with in some parts of the Andes, it is true, but despite these difficulties the tin mines of the State of Bolivia alone have been so successfully exploited that the country already ranks second to the Straits Settlements as a tin-producing district. Last year the mines of Bolivia yielded about 18,000 tons of metallic tin, the world's total production being about 113,000 tons, of which the Straits produced 56,000 tons, England (including production from foreign ores) 14,000 tons, Dutch East Indies 13,000 tons, Australia 9,000 tons, and Germany 6,000 tons.

It is highly probable that output will continue to increase substantially, not only in Bolivia, but in other parts of South America. One of the difficulties encountered in that part of the world hitherto has been the unstable character of government in some of the South American States. Mining titles have not always been secure, hence water conservation and the introduction of up-to-date machinery have been at a decided discount. But government conditions are improving, and will improve, and capital and enterprise will meet with more encouragement.

In some parts of South America the ore yields 10 per cent. of metallic tin. In others the yield is much lower, as low as 3 per cent., and less in fact, and costly plant is necessary. This is now being introduced, and with more ordered government, a healthy and progressive development of South American tin-mining, to say nothing of other minerals which abound, may be confidently expected. Already a good deal of British and American capital has been sunk in Bolivian tin-mining, output has been increased at a fair rate, and the prospects seem to be improving every year. In the last three or four years Bolivia has increased its contribution to the world's tin supply by about 1,000 tons a year, while other tin-producing countries (excepting Australia) have either failed to improve their positions substantially, or else have lost ground.

In Peru little tin has been found yet; but there is a positive abundance of ores containing a low percentage of tin, which may possibly be exploited in the future. In the

* Cassier's Magazine, May, 1907.

Province of Catamorca, Argentine, tin of low grade has been found recently, and, it may be added, manganese in large quantities. Coal of excellent quality has also been discovered in Bolivia.

Probably the worst natural difficulty met with in South America tin-mining is the altitude of most of the deposits so far located. In the Quinsa Cruz district, for example, the richest yet discovered on the continent, the best deposits are more than 15,000 feet above sea-level. Here only natives can do labouring work, and these are not particularly industrious. Possibly — probably — good, workable deposits may yet be found lower down the Andes, or in other parts of South America. There is much ground for the prospectors to go over yet.

Turning our attention next to the East, we find the outlook not so bright, that is, so far as present knowledge enables us to judge the prospects. The Straits' output seems to be steadily declining from year to year. It is known that tin has been mined in that part of the world for quite three hundred years, and it is contended that many of the deposits there are being exhausted. Certainly the yield per ton is diminishing, and the cost per unit of output is going up, while the total output of several of the principal mines, and this is the most important point so far as our purpose is concerned, is declining. But all the evidence from the East is not of a pessimistic character. Against a material decline in the shipments last year from the Malay Peninsula and the Straits Settlements proper, there was a gratifying increase from the neighbouring islands of Banka and Billiton, from which, in the three or four previous years there had been recorded decreases, as in the case of the mines of the Peninsula.

But even in the case of the Settlements the decline in output is in reality as largely due to artificial as to natural drawbacks. There is just as much a shortage of labour as of ore, and there is a somewhat remarkable lack of efficient plant and appliances at some of the mines. If more coolie labour were available, or if the present primitive methods of sluicing and panning were abandoned, output might be increased on the Peninsula as it has been on the two islands just named. The combined output of Banka and Billiton was greater by some 2,000 tons last year than in 1906. So far as the labour difficulty is concerned, some improvement is being effected. The mine owners in the Malay States are finding that, by leasing out portions of their properties to the coolies, better results are obtained than by direct labour supervised by European managers. With a further extension of this contract system, and with better appliances, output may possibly be maintained, if not increased. Indeed, in a recent report the Acting Senior Warden says he sees no cause for alarm, and is of opinion that no evidence is forthcoming to show that the deposits of the country are nearing exhaustion.

In Siam recent geological investigations encourage the hope, if not the belief, that a very largely increased output is possible in that country. Several mines are being worked now, and the prospects are good. Indeed, the mountains throughout the Indo-Chinese Peninsula, of which Siam is a part, are very rich in tin, and capable of great development in mining. It is not at all improbable that this peninsula may some day rival the neighbouring Malay Peninsula in tin production.

In some parts of China tin has been worked for hundreds of years, and as large portions of that great country remain untapped, it is not unreasonable to assume that positively large deposits may be found there. The Kuo-Chin mines, with very primitive appliances, are now being worked successfully.

In other parts of the vast con-

tinent of Asia there are enormous tracts of land unexplored for minerals. It is known that there is a good deal of tin in India. In the Tenasserim Provinces of Upper Burma there are rich deposits of tin.

In Africa, too, tin has recently been found in more than one place. From Northern and Southern Nigeria and the Congo, encouraging reports have been sent lately. We understand that a movement is on foot now among some European capitalists to exploit the deposits found recently in the neighbourhoods of Uwet, Bantchi, and the Lualaba River. A Government report, dealing with Southern Nigeria, says "tin-stone of good quality has been found, and the question of the development of the stream tin deposits so far discovered is ripe for practical consideration."

In the Cape Colony and Transvaal the prospects are also good. At the Knils River tin mines, in Cape Colony, a new process for the concentration of alluvial tin has recently been adopted, and is giving excellent results. In the Transvaal, tin is being found in very promising quantities. The *Mining Journal* (London) reports "A new company has just been registered . . . for the purpose of working a property in Switzerland . . . the area covered by the concession is thirteen and a half square miles, and the title for fifty years, with right of renewal at a royalty of 2½ per cent. of profits. . . . The ground is said to be of the same geological character as that on holdings now being successfully worked." The prospects of another company recently formed to carry on tin mining in the Transvaal are reported to be extremely satisfactory.

Nearer home, in Spain, some old and abandoned tin mines, abandoned when tin was cheap, are about to be reopened. And in Austria there are some tin-bearing ores which might prove profitable with the metal at its present price.

In England fresh capital is being invested in tin-mining enterprises, with very reasonable hopes of success. Mines which would not pay when tin was cheap and appliances primitive will pay now. We look for more substantial increase of output from the Cornwall mines these next few years, unless the price of tin comes down much lower than anyone expects.

About twelve years ago, when tin was not half the price it is today, many mines were closed down in Cornwall. Most of these mines will now pay for reopening. Cornish tin is probably the best in the world, and the whole county is streaked with it.

But it is, in our opinion, to the Australasian colonies that we can look most confidently for future supplies of tin. In Tasmania and Australia there are positively vast deposits of tin-bearing ores. In Western Australia only about 1,000 men are employed in tin mining, yet the colony is very rich in tin-bearing ores. The tin is there; only capital and labour are needed to produce a big output. In Queensland good profits are now being derived from tin mining, and there is nothing to prevent increased production. Very rich and extensive deposits have been located quite recently in that colony. In New South Wales expansion is taking place in the tin-mining industry as rapidly as the supplies of capital and labour will permit. Not very much is being done in lode mining, but in dredging there is great activity, substantial progress, and excellent prospects. It is true that there is difficulty in treating some of the material, but with the progress of metallurgical science this will diminish, if not disappear. In Victoria great progress is being made in dredge mining for stream tin, and promising alluvial deposits have been found in the Northern territory of South Australia.

In Tasmania, although some of the

best lode mines have either been worked out or are approaching exhaustion, there are enormous reserves of lower grade ore which, with improved methods of mining and treating, can and will be worked as successfully in the future as the richer ores in the past. Indeed, the latest reports are of a most encouraging character. Alluvial deposits are yielding well. Tasmania is certainly capable of becoming a very great tin-producing colony. Australia and Tasmania could easily make good any deficiency in the world's tin supply that may be caused through declining output of the Straits Settlements, and more than make it good, assuming that the Straits' output continues to decline, which is by no means a certainty. The price of tin may remain high, but we venture to predict that a tin famine on account of Nature's niggardliness is, like a coal or iron famine, a long way off.

# THE BERLIN MARINE EXHIBITION

By Max A. R. Bruenner

UNTIL a comparatively recent date the shipbuilding industry was by no means so far advanced in the German Empire as in other European nations, a fact which was sometimes made the subject of rather unpleasant criticism. At the present time, however, this important department of engineering and structural work has attained a very high position, both as regards the character of the vessels and the quantity of work done; and in the merchant marine and in naval development it stands in a prominent position. In order to demonstrate to the great mass of the people, many of whom have had no opportunity of obtaining an insight into this industry, and to develop still further interest in its advancement, it was arranged to hold a special exposition in Berlin devoted wholly to shipbuilding and related matters.

It is well known that the Emperor has the development of the German navy closely at heart, and hence he took the greatest interest in the plans for this exposition. In fact, he shows this interest in naval matters on all possible occasions, being present at all important naval manœuvres, launches, regattas, etc., although taking little notice of racing and similar sports. This interest is shown in the present case by the fact that he is an exhibitor himself and has loaned numerous models of yachts and warships, as well as prizes won at regattas. A quantity of remarkable material has also been contributed by the Government, and it is believed that the show is the most complete which has been given to the subject anywhere.

The two lower halls of the exposition are really not large enough to contain all the exhibits, but a walk through them affords an excellent insight into the difficulties encountered by the German shipbuilders during their first efforts to construct a modern battleship or great ocean liner. Naturally these efforts had to be exerted in competition with other shipbuilding nations, and especially with Great Britain.

The superiority of Great Britain in the shipbuilding industry is due to a number of evident reasons, especially to the large supply of coal and iron in close proximity to the great ports and shipyards. In Germany the materials must be obtained chiefly from Silesia and Westphalia, far from the coast. Besides, by the middle of the last century England was a great maritime nation, with large colonial possessions and with an important merchant marine and important navy, while Germany was a conglomeration of small States, possessing neither commercial nor naval vessels of any consequence. Such vessels as were built in Germany at that time were made from iron and other materials imported into Germany in the face of a high duty.

It was only after the Franco-Prussian war and the foundation of the German Empire that any considerable change took place and the construction of a navy built, as far as possible, from home material, was undertaken. A period of intense activity followed. The steamship subvention law required vessels receiving subsidies to be built in German yards, but for other work an active struggle took place in which

sometimes England and sometimes Germany was ahead. By the early eighties Germany was producing iron and steel at prices which could compete successfully with the products of the British works. Krupp produced his famous cast steel and began the manufacture of armour plate of the heaviest kind and of the highest grades. England developed the Bessemer process, and Germany responded with the Siemens-Martin system. Also in Germany there appeared the process for the manufacture of seamless tubes, suitable for boiler flues, and seamless shells, both valuable in marine work, and so the competition went on.

As the work progressed it had its influence upon allied industries, and the manufacture of such appliances as cranes and heavy hoisting machinery became extended. Formerly Germany was obliged to depend upon British dock-yards, but she soon learned to build her own. Thus much of the valuable and lucrative business of repairing ships was diverted to Germany. An important feature of this element in the development of the industry lies in the fact that the weak points of ship construction are revealed in the repair yards, and as soon as Germany acquired her own docks much valuable experience was gained at good profit. Many of the associated industries began to feel the advantages of the development of German shipbuilding, such as the production of the interior fittings, furnishings, etc., including the manufacture of steel furniture required for warships. Even such small, but important, articles as screws, bolts, chain, rivets, pulleys, rings, nails, etc., were no longer imported from abroad. Especially in the matter of electrical machinery, Germany soon overtook England in adapting such appliances for use on shipboard, applications which now are most extensively employed in every conceivable manner.

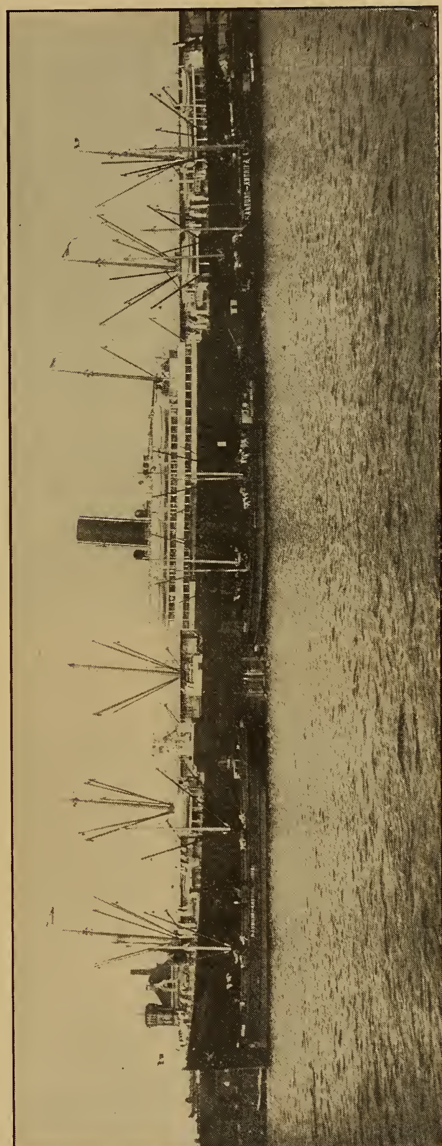
POSTER OF THE BERLIN MARITIME EXPOSITION, SEEN EVERYWHERE IN THE CITY

In addition to the exhibits directly connected with marine engineering must be mentioned the contributions

THE KOENIG WILHELM II., A NORTH GERMAN LLOYD STEAMER BUILT FOR SERVICE IN THE TROPICS. SHOWN BY MODEL AT THE EXPOSITION

made by the great educational institutions of Germany. The technical schools of Charlottenburg and Danzig have special courses in shipbuilding, the German Emperor having attended some of the lectures, while special schools devoted to shipbuilding have been established at Hamburg, Bremen, and Kiel. There has also been organized a professional society, the *Schiffbautechnische Gesellschaft,* or Shipbuilding Technical Society, an organization which is continually making investigations and researches upon matters relating to shipbuilding, such as the strength of materials, the design of bulkhead doors, the resistance of water, the vibrations of vessels, the efficiency of propelling machinery, maritime law, insurance, etc., and is thus contributing most valuable information both to the shipping industry and the art of marine construction. The Emperor is an honorary member of this society and frequently attends its meetings and joins in the discussions. The result of this development has been the attainment of such a high degree in quality of material, workmanship, and perfection of product, that exports of apparatus to England, the United States and other countries have reached large proportions.

Soon after the foundation of the German Empire the determination of the government to develop a German navy caused the yards to become active. The start had been made by Prussia in 1842 with the construction of the sailing vessel *Amazone,* carrying 16 guns; followed, in 1848, by gunboats made partly of wood and partly of steel, and models of these early ships are shown at the exposition. When the first wooden steam-corvette *Danzig* was built, in 1850, the engines, costing $20,000, had to be imported from England, and a duty of $20,000 paid in addition. It was also necessary to



THE PRESIDENT LINCOLN, A MODERN COMBINATION PASSENGER AND FREIGHT STEAMER

import from England a wharf crane to enable this machinery to be placed in the ship. The first armoured vessels built in Europe were made in German and French yards, the first German one being the armoured corvette *Hansa,* of which a model is shown. It was not until the large cruisers *Grosser Kurfurst, Friedrich der Grosse* and *Preussen* were built entirely in German yards, including the engines and all accessories, that Germany felt that she could stand on her own feet, both as regards material and workmanship.

The progress thus made produced a revival in other industries, especially in the quality and quantity of iron and steel produced. Efforts to encourage the employment of well-educated engineers from the Royal Trade Institute aided in the development of the theoretical side of the industry, and soon, instead of importing vessels, Germany began to build them for other countries. This is demonstrated at the exhibition, where will be seen designs of warships built for Russia, Italy, Denmark, Norway, Greece, Austria, China, Japan and Brazil. As early as 1877 the first sea-going torpedo boat was built by the Schichau works at Elbing for the Russian government. By the beginning of the eighties the same firm built torpedo boats for every European navy except those of France and Great Britain. These were followed by orders from China for cruisers, and for torpedo boats from Japan and Russia, these being built in the yards of Danzig, Elbing and Kiel. Later came the modern battleships of the *Brandenburg* class, cruisers of the *Hertha* class, and high-speed, triple-screw steamers.

The German merchants at first took little interest in the construction of the German-built naval vessels. Their relations with the British business world had been long and satisfactory, and they were not prepared to make the risk of changing from the well-tried and experienced British shipbuilders to those of the home country with but a few years behind them.

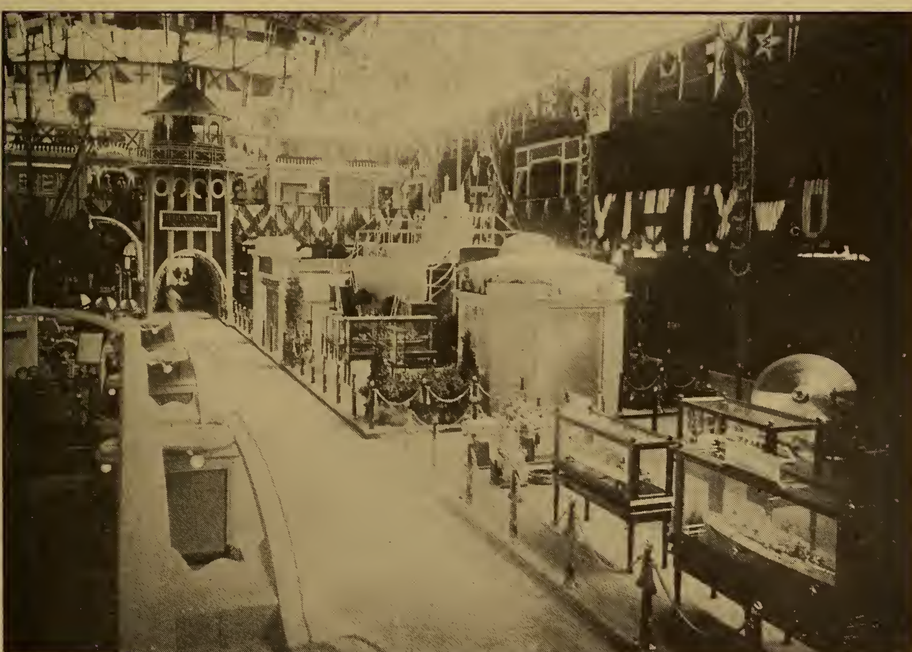
The high price of raw material in Germany at that time, and the primitive condition of the appliances, made economical production difficult, and thus the work continued for a time to be placed abroad. During the years from 1881 to 1887 the North German Lloyds alone placed orders

GERMAN TRAINING SHIP GROSSHERZOGIN ELISABETH. A SILVER MODEL OF THIS VESSEL IS EXHIBITED BY THE EMPEROR WILLIAM

amounting to forty million marks with a Glasgow firm, an example of the extent of this department of work. In the meantime the German iron industry had developed to an extent which enabled it to meet foreign competition. As a result the Hamburg-America Line, in 1882, ordered two of its largest steamers, the *Rugia* and the *Rhaetia*, to be built in German yards. In 1885 the steamship subvention law was enacted, and the first order, amounting to 9,500,000 marks, was placed with the Vulcan Works, at Stettin. Although the order was executed with great satisfaction, the builders lost 1,750,000 marks, as they had never built such vessels before, and were obliged to make many costly models and patterns and instal new tools. The experience thus gained was most valuable, however, and the loss was soon repaid from new orders. The Vulcan Works has the largest space of any private concern at the exposition and it includes models of every ship built by them during the past fifty years.

When the Hamburg-America Line decided to introduce fast steamers, making speeds of 18 to 19 knots, a number of British and German builders were invited to compete. Finally the Stettin firm was chosen, but the order was coupled with the difficult condition that the builders were to take the vessel back in case it failed to make the required speed. As the firm had never built fast steamers, this was an especially serious requirement; but the success attained resulted in additional orders, and the following vessel, *Fuerst Bismarck,* attained a speed of 19½ knots, being the first to make a transatlantic record. Some time later the North German Lloyds ordered the *Kaiser Wilhelm der Grosse,* under the condition that the vessel must attain a speed of 21 knots. At a risk of several millions this order was taken, and on its first trip the ship made a speed of 21.39 knots, and subsequently reached a speed of 22.56 knots, proving the excellence of design and construction. Then followed in rapid succession the other

MAIN HALL OF THE EXHIBITION. THE STATUE OF THE KAISER IS AT THE REAR END, TOGETHER WITH HIS EXHIBITS



GENERAL VIEW OF BERLIN MARITIME EXPOSITION

high-speed liners, which have carried many thousands of passengers across the Atlantic and are known to every foreigner. Until recently, the speed record, the "blue ribbon" of the Atlantic, was held by the German vessels, but last year it was lost to the new British vessels *Mauretania* and *Lusitania*. Attention may be called to the fact that this is rather an absolute than a relative victory, since the new Cunarders have about 14,000 horse-power more than the most powerful German steamer. It is understood that the leading German lines, realizing that such vessels are not profitable commercially, have decided not to undertake their construction, since they require the backing of Government subvention, as is the case in Great Britain.

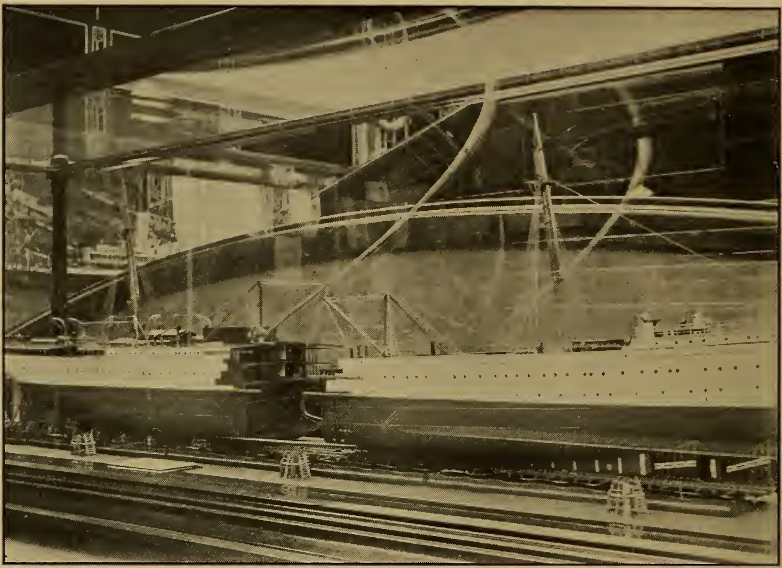
Hand in hand with the rapid development of German shipbuilding has gone the improvement in sailing vessels, vessels for special purposes, and appliances belonging to the shipping industry, such as docks, equipment, cranes, machines, tools, etc. Such immense vessels can be built to advantage only by the use of the most effective machinery. Special machines for planing and riveting the parts had to be designed and built, while the works had also to be equipped with transportation appliances similar to those used in American shops. There is now hardly any works in Germany which is not provided with a network of shop railways, traveling cranes, turntables and efficient wharf cranes. Electricity and compressed air are largely employed, and the machinery is of the most modern design.

MODEL OF THE SHIP PREUSSEN, THE LARGEST SAILING VESSEL IN THE WORLD

The requirements of the industry will be better understood if we consider the immense amount of work to be done. Thus, in the construction of an average ocean liner about two million rivets are required, and there are about twenty-five miles of

EXHIBITION OF TYPICAL PARLOUR ON HAMBURG-AMERICA LINER

EXHIBIT OF A-LA-CARTE RESTAURANT ON THE AMERIKA



MODEL SHOWING THE OPERATION OF LENGTHENING A STEAMSHIP

seams and joints to be made water-tight. An important department of work is the improvement of older vessels by cutting in two and lengthening, an operation formerly done almost entirely in England. In many cases this has proved more economical than the construction of a new ship, and it has been effectively done in Germany. The construction of stationary and floating docks has also been developed, and at present 37 docks are in general use, of which 29 are of the floating type. To these must be added 22 belonging to the Government yards, and the two owned and used by the North German Lloyd and the Hamburg-America Line. At the present time there is being constructed at the works of Blohm & Voss a dock of 38,000 tons capacity, which will be the largest in the world. A dock of 36,000 tons capacity is also under construction at the Stettin works. Well-executed models of these docks and their appliances are exhibited at Berlin.

Both the North German Lloyds and the Hamburg-America Line, being the largest shipping concerns, have taken much space at the exhibition, and they have hung up large diagrams showing the number of vessels ordered at home and abroad. From these diagrams it appears that during the first half of the existence of these companies by far the greater portion of their vessels were built in foreign yards, chiefly in England. At the close of the last century the orders were divided about equally between the home yards and abroad, while at the present time it is comparatively rare to find a steamer ordered elsewhere than in a German yard. Similar diagrams are shown by the Government for naval vessels, and the transfer of the work from British to German yards is still more noticeable in these, as it began earlier and was effected sooner. During the last ten years not a single German naval vessel has been built abroad, while on the other hand the German yards have had numerous orders from other governments.

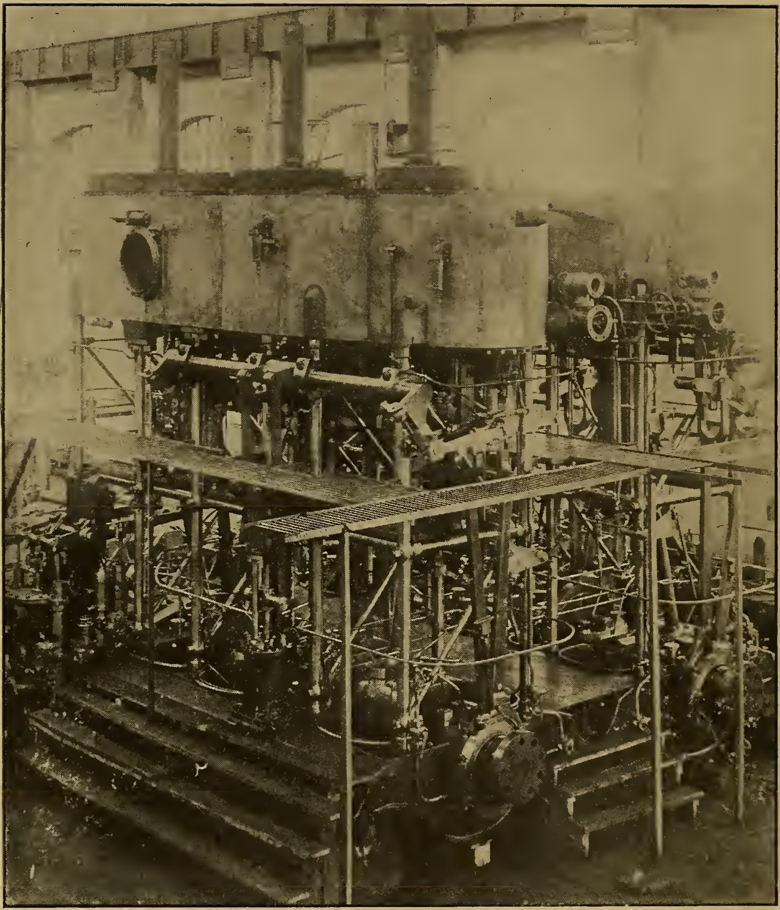
As has already been said, the remarkable development of German shipbuilding had a favourable influence upon the iron and steel industry, and this development reacted upon the shipbuilding industry as regards quality of material. There

PANORAMA OF THE HARBOUR OF HAMBURG, AS SEEN FROM THE DECK OF A STEAMSHIP

was also created a market for small articles, accessories, etc.

There are now in existence special works devoted to the manufacture of valves, pipe, railings, screws, tackle, gears, rivets, nails, chains, hooks and many other articles of bronze, copper and iron. Auxiliary machinery has been greatly improved, including pumps, water purifiers, superheaters, injectors, boiler fittings, windlasses, steering machinery, cooking appliances, refrigerators, toilet equipment, and last, but not least, interior furnishing and nautical instruments. It is now many years since the German

A PORTION OF THE EXHIBIT OF MARINE PAINTINGS IN THE GALLERY



TRIPLE-EXPANSION MARINE ENGINE EXHIBITED BY THE ROYAL INSTITUTE OF MARITIME SCIENCE

shipbuilders have been freed from the necessity of importing such articles, and a considerable export trade has been built up. Especial progress has been made in the development of electrical appliances, and the products of the German makers in this line remain unsurpassed. Nearly all these appliances are shown at the Berlin exposition, partly as originals and partly as models.

The exhibits of the German schools show the superiority which has been attained in this respect. As long ago as 1861 a department of shipbuilding was instituted in the Royal Trade School at Berlin, an institution which was subsequently incorporated into the great school at Charlottenburg.

Many of the leading designers in the present yards obtained their education in this institution. Since 1904 there has been a similar school at Danzig.

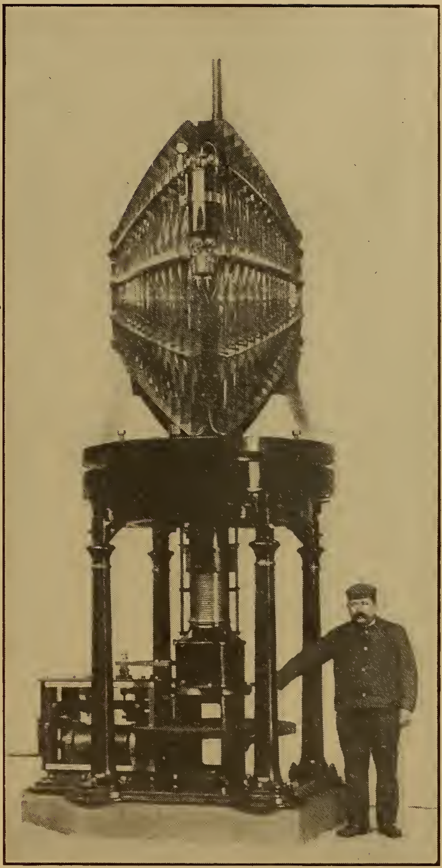
In addition to these there must be mentioned the various associations, such as the Germanic Lloyds, and the rules and regulations adopted by these are well known at home and abroad. These institutions have contributed much valuable material to the exhibition, such as drawings, books, models and information.

At the beginning of the present century, then, German shipbuilders

could look back proudly over a splendid development, a development which even her former instructor, England, fully recognized. The fleet law of 1898 could be carried out with the required promptness, and the efficiency of the battleships belonging to the *Wittelsbach, Braunschweig* and *Deutschland* classes exceeded their requirements. Similar increase in size and power was made with merchant steamers, and in 1905 the *Kaiserin Auguste Victoria* was launched at Stettin, the weight of the hull alone being 15,300 tons, with a capacity of 14,000 tons and a displacement of 43,000 tons, being the largest vessel then built. The ornamental excellence of the interior furnishing of these German vessels is well known, a noteworthy example being found in the *Kronprinzessin Cecilie.* A number of fully-equipped cabins, dining rooms, parlours, smoking rooms, toilets, baths, kitchens, etc., are shown full size at the Berlin exposition, giving an excellent idea of this department of the work.

The construction of vessels for special purposes has not been neglected in this development of German industry, and the yards have been actively engaged in building tank steamers, dredges, ice breakers and vessels for the transport of cattle, meat, grain, and the like. A special type of vessel is that designed for the laying of telegraph cables, and a model of such a ship is exhibited. Progress has also been made in wrecking boats for saving stranded vessels, and one unique example in this department is seen in a boat for saving submarines, this also acting as a reserve ship and provided with electric power, which may be supplied to its associates. In this type, built especially for the German navy, the propeller is driven by electric motors receiving current from primary turbo-dynamos.

In the exhibition full-size sections of two submarines are shown, and these attract much attention, since this is the first opportunity given to the public to examine such vessels.



LIGHTHOUSE EQUIPMENT, SHOWN FULL SIZE AT THE EXPOSITION

Sporting boats have not yet attained the development in Germany which exists in England and the United States, but much progress has been made in the past ten years. Numerous clubs devoted to motor boats and to yachting exhibit handsome models of fine vessels, while prizes won at home and abroad are shown, together with pictures of important events.

The whole exhibition is a demonstration of the story of the development of German shipbuilding; but it would require several days to see everything, owing to the complete-

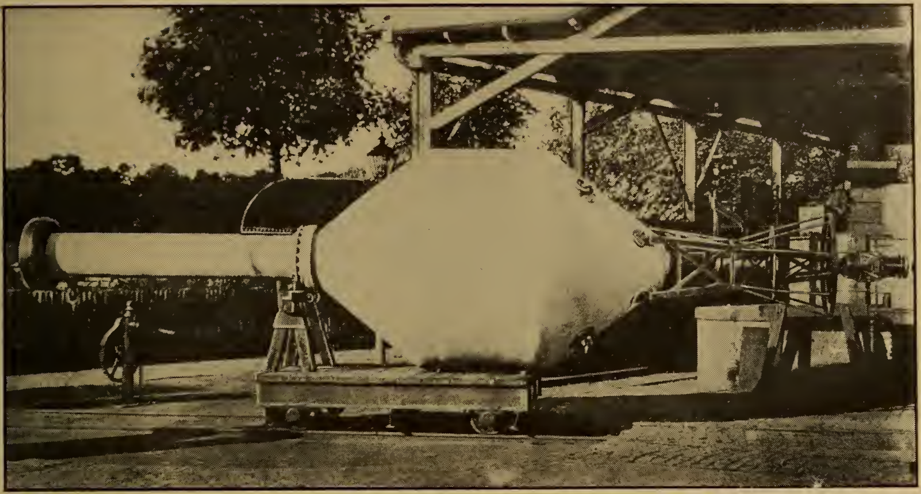
A HAMBURG STOREHOUSE. MODEL SHOWN AT BERLIN EXPOSITION

ness of the show. The objects belonging to the Emperor are naturally a center of attraction. These are all made of silver and contained in glass cases. Their value appears, however, not only in the costly material, but in their historical importance, as they enable the general development of shipbuilding to be followed. The oldest example in this section is a Viking boat of the ninth century, the original being 24 metres long, this being followed by a Norman vessel of the twelfth century, by a Mediterranean galley, by the British man-of-war *Great Harry,* and by the first vessels of the Prussian fleet. A model of Nelson's flag ship *Victory* will appeal to British visitors, while, on the other hand, models of very modern boats include the German training ship *Grossherzogin Elisabeth,* and the Kaiser's own yachts, *Iduna, Comet* and *Meteor.*

Among the other royal exhibits the splendid collections of Prince Henry and the Grand Duke of Oldenburg may be mentioned.

These models are made mostly of wood, with some of silver, and they include gifts from foreign rulers, presidents and authorities during the travels of Prince Henry. Among these is a Siberian bark boat, Japanese sail boats, Brazilian fishing boats, the Siamese State Gondola and some modern German warships. The Royal Institution for Maritime Science has an exhibit of engines and boilers, many of which are historical types, no longer in use, but furnishing excellent material for the student. The Imperial Navy Administration has loaned some models of the oldest warships, which otherwise could not have been obtained, among these being the first German warship *Amazone,* built in 1853, being entirely of wood and 26.4 metres long.

Private builders show their products chiefly in the form of models, of which there are several hundreds on exhibition. In this way the visitor can follow the development of the sailing vessel, freight steamer, ocean liner, battleship and torpedo boat. In like manner he may study the interior construction, the arrangement



A SIGNAL BUOY EXHIBITED OUTSIDE THE MAIN HALLS

of the decks, the mechanical equipment, the telegraph and telephone apparatus, the signalling, lighting, safety and sanitary appliances, as well as the extended use of electricity, and everything which has to do with shipping and shipbuilding.

In general the exhibition consists of the two largest halls available in Berlin, completely filled, together with long galleries, an extra pavilion outside, and the court yard, there being 205 exhibitors, with more than 2,000 objects.

Many of the foreign visitors, especially the Americans, inspect with interest the models of the numerous vessels which they know from actual use or have seen in the harbour of New York. They are also interested in the German-American sea post office, of which a full-size exhibition is given, and which enables some idea to be obtained of the tremendous amount of mail carried by a transatlantic liner. The greater part of the mail has to be carefully examined and the letters classified, so that on the arrival in New York they may be immediately dispatched, whereas formerly a day was lost by doing this work on land. German

MODEL OF THE CABLE-LAYING STEAMER STEPHAN

RUSSIAN MAIL STEAMER OKEAN, BUILT IN GERMANY. MODEL SHOWN AT BERLIN EXPOSITION

and American high post-office officials always accompany such a boat, together with two or three assistants, the number being increased at Christmas, when a number of empty cabins have to be used to take the excess crowded out of the post office.

Other interesting exhibits are examples of a workshop on shipboard, with all the tools and machinery, an immense kitchen, a sea hospital, with operating room, a gymnasium, cabins for warships fitted in the German style with all fittings, furniture, ceiling and walls of asbestos, storage rooms, etc. In the gallery there is a fine exhibit of marine paintings, also a theatre with moving pictures showing the building of a large ship, from the designing in the draughtsman's office to the launching, an excellent and instructive object lesson.

Hundreds of thousands have already visited this interesting special exhibition, with the result of extending widely the knowledge of the development of marine and naval engineering in Germany.

# GAS PRODUCERS FOR BITUMINOUS COAL

By Oskar Nagel Ph. D.

FUELS which are high in fixed carbon and low in volatile matter, that is, hard fuels like anthracite coal, coke and charcoal, are readily gasified in ordinary producers, the apparatus consisting practically of an iron shell, with fire-brick lining, a mixture of air and steam entering at the bottom and the gas leaving at the top, after giving off the greater portion of its sensible heat to the upper layer of green coal.

When bituminous coal is to be gasified, however, it is necessary to provide either some additional apparatus for the removal of the tar, or some device to prevent its formation. If we consider that every ton of coal converted into producer gas generates ten times as much gas as in the manufacture of coke, we can see that an apparatus for the complete removal of the tar must necessarily be of very considerable size. It is therefore desirable to prevent the formation of tar, thus reducing the complication of the apparatus, and also utilizing the calorific value of the tar, instead of allowing it to go to waste.

In order to prevent the formation of tar the gas producer must be so arranged that the volatile constituents are decomposed, as far as possible, into hydrogen and carbon monoxide, for which reaction a high temperature is necessary. In approaching the incandescent part of the fuel bed the tar is liberated. It is for this reason that soft coal, used in an ordinary producer, generates a gas high in tarry contents. If the tarry gases are passed again through incandescent coal, the tar is converted into a fixed gas of high thermal value, consisting of hydrogen, carbon monoxide, and some carbon dioxide.

Several methods have been proposed for the removal of the tar in the producer itself, by decomposition in the zone of combustion. One of the simplest methods to this end appears in the down-draft system, of

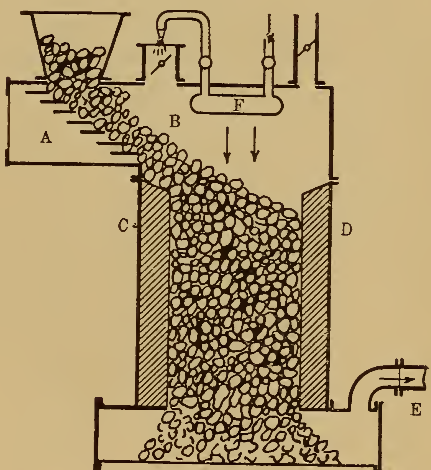



FIG. 1.—THE LETOMBE PRODUCER

which the Letombe producer is an example. In this arrangement the green fuel is at one side of the zones of combustion and reduction. The fuel is charged upon the inclined step grate *A* at the top, the air entering through the grate causing a partial combustion of the fuel and the distillation of the volatile matter. The bulk of the air, together with the moisture, enters at *B*, producing the zones of combustion and reduction at *C* and *D*. The gas is discharged at *E*. A small boiler *F* supplies the vapour necessary for the required amount of moisture. A

number of these producers have been installed, and in Mexico they are reported as having given good results with wood. The principal criticism to be made of this design is, that the accumulation of ash and slag behind the combustion zone is inconvenient.

Another method of getting rid of the tar is to collect the gases of distillation separately in the upper part of the producer, and then deliver them, by means of outside pipes and a steam jet, into the lower part of the producer, so that they pass through the fuel bed a second time, together with the fresh-air supply.

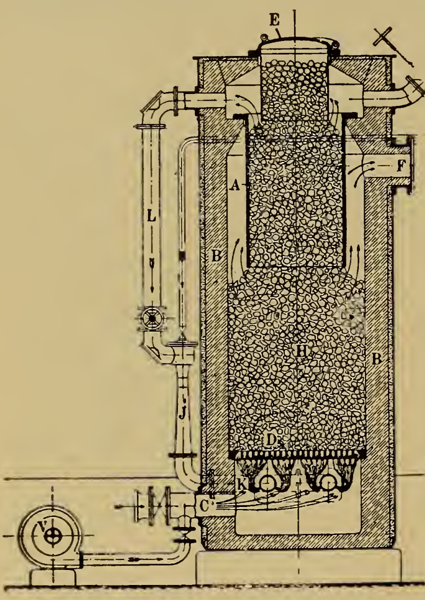



FIG. 2.—THE PINTSCH PRODUCER

It has been found to be a very difficult problem to accomplish this successfully, and the quantity of tarry gases is not definitely known. Many producers upon this principle have been designed and operated with more or less success.

An example of this type of producer is that of Julius Pintsch, of Berlin. Here the green fuel contained in the fire-clay chamber *A* is heated by the gas as it passes out at *F*. The products of distillation are drawn off from the top through the pipe *L*, by means of the jet ex-

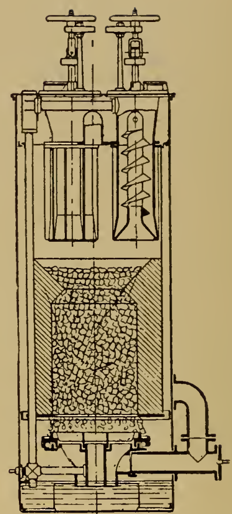


FIG. 3.—THE CROSSLEY PRODUCER

hauster *j* and delivered into the bottom of the producer, where they mingle with the incoming air and pass up through the fuel bed *H*. A producer of the suction type, constructed according to this principle, is stated to be in successful operation in Denmark, using a mixture of coke and bituminous coal.

In the Crossley producer, shown in the illustration, the green coal is treated in retorts suspended in the upper part of the producer, these retorts being opened from time to time to permit the coked fuel to fall into the producer. The tarry gases are conducted to the bottom of the producer, as in the Pintsch type.

A natural variant of the above principle appears in the use of two producers, one fed with bituminous

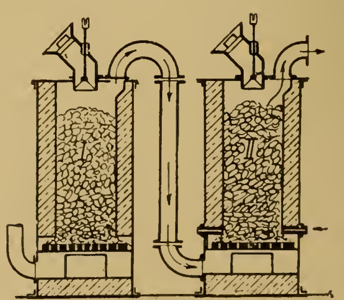


FIG. 4.—DOUBLE PRODUCER

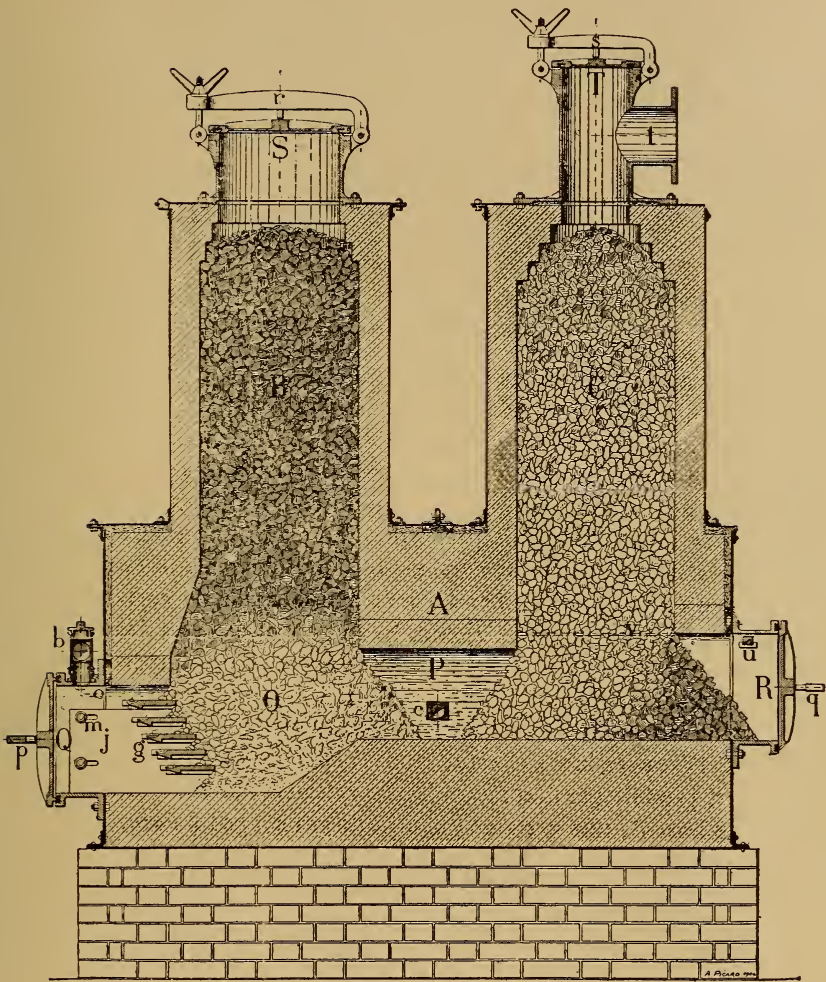



FIG. 5.—RICHE DOUBLE PRODUCER FOR WOOD AND COKE

coal, the tarry gases being passed through a second shaft charged with anthracite or coke. The Riche producer is designed on this principle, using wood in one shaft and coke in the other. A specially interesting construction for the use of two kinds of fuel appears in the inclined producer of Lencauchez. Here both fuels are used in one shaft, the inclined position causing them to remain separated. The coke is on top, so that the tarry gases produced from the bituminous coal are compelled to pass through it.

Some successful experiments in the production of a gas free from tar, using but one kind of fuel, have been made with a producer having two zones of combustion. An example of this type is seen in the Körting producer for gasifying lignite briquettes. The fuel is coked in the upper combustion zone *A,* where the distillation takes place, the quantity of air admitted being regulated by a slide. The tarry gases travel downward to the second combustion zone, the gas being taken off at *B;* the air supply for the second zone of combustion enters through the grate. With this apparatus a gas has been

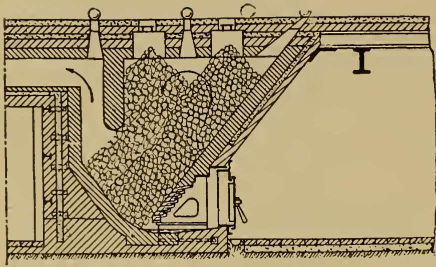


FIG. 6.—LENCAUCHEZ INCLINED PRODUCER

obtained from peat or lignite containing a little tar or impurities, as gas from anthracite coal. This seems to point out the way for the successful gasification of bituminous coals.

Finally, we may mention the Jahns producer, in which the lowest grades of bituminous coal, with a fixed-carbon content as low as 25 per cent., may be converted into gas free from tar.

Jahns generally combines four producers into one group, these being charged alternately with green fuel. The moist and tarry gases generated in the shafts containing the green coal are caused to pass through the adjoining shafts of the same group which are in full incandescence. In the Jahns system the shafts are alternately charged completely and entirely emptied. By allowing the large quantities of incandescent clinker to remain under the producer, the fresh charge can be quickly heated up. In actual practice, however, it has been found preferable to charge and discharge the

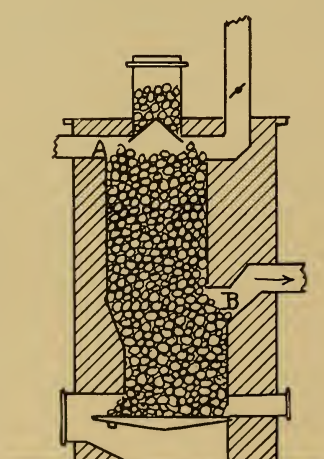



FIG. 7.—KORTING PRODUCER FOR LIGNITE BRIQUETTES

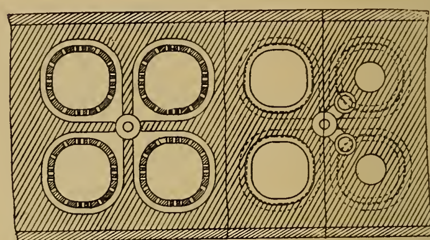


FIG. 8.—SECTIONAL PLAN OF JAHNS PRODUCER

shafts gradually. The arrangement of the Jahns producer system will be understood from the sectional elevation and plan.

In the Mond system the coal is

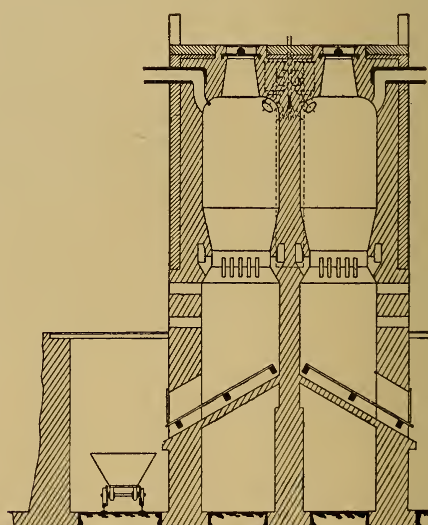


FIG. 9.—SECTION OF JAHNS PRODUCER WITH FOUR SHAFTS

gasified for the purpose of recovering all the by-products, especially the ammonia, but the initial cost of this system renders it particularly available for very large units. Since all the by-products are utilized, the gas is very cheap.

# THE MECHANISM OF A TAXIMETER

By J. F. Gairns

ALTHOUGH the use of taximeter instruments, usually adapted for both time and distance hiring, is not necessarily associated with motor-propelled vehicles, and a number of such instruments have been and are in use for horse-drawn cabs and like vehicles, it is principally in connection with motor-cabs and similar vehicles that they have come prominently before the public and have received their most extensive introduction. To-day the motor-propelled cab is a matter of everyday life in London, upwards of a thousand of such vehicles being in regular service, while in other great cities of the world, such as Paris, Berlin, New York, etc., their use is becoming increasingly general. The taximeter is consequently continually under observation in these cities, and its main external and indicative characteristics are fairly well known; but its internal construction and mechanical operation are comparatively little known and understood, even by engineers, unless they have had to examine and deal with such instruments. It is therefore thought that a description of the mechanism of one of the standard makes of taximeter apparatus will be of interest; and for this purpose the "Aron" taximeter, as now fitted in large numbers by the General Electric Company, Ltd. (of London and Manchester), has been selected.

This apparatus has been developed, as regards detail features of the mechanism, from electric and other meters, the Aron electricity meter being well known, while the makers have had considerable experience with various classes of recording and allied apparatus. The main interest, therefore, lies in the assemblage of the different mechanisms for taximeter purposes, the relation of one section to another, and the adaptation of the whole to provide an apparatus that is comparatively cheap, simple and reliable, which is easily manipulated by the driver and readily understood by a passenger. It is necessary that it shall, at the same time, comply with police regulations, provide complete record of a day's work and a check upon the driver, and yet be adapted for recording either by time or by distance, or a combination of both according to the varying conditions of hire and travel.

The accompanying illustrations will give an idea of the construction, manipulation and operation of the apparatus; but before going into mechanical detail a few remarks concerning the general feature will be in place.

The apparatus is usually affixed to the side of the vehicle, whether horse-drawn or motor-propelled, at a convenient height so as to be easily observed both by the passenger and by the driver without turning, and to be readily noticeable by a would-be hirer as regards the indication as to whether the vehicle is "engaged" or "for hire." This latter indication is given by a lettered tablet, or "flag" as it is usually termed, this being displayed as shown so long as the vehicle is not engaged. When a passenger is taken up, or a vehicle is engaged—there has been considerable discussion as to whether the fare should be reckoned from the moment of calling or when actual use commences, but it appears to be


FIG. 1.—THE TAXIMETER IN POSITION ON THE VEHICLE

settled now that charging should reckon from the time of calling, with perhaps a little latitude when reasonable—the driver moves the flag downwards by means of the handle *A* on the flag post, and this movement causes the word "Hired" to be exhibited in place of the words "For Hire" on the main dial, and the initial charge is shown under "Fare." By means of a handle at the back the driver can then charge for "Extras," such as additional persons, luggage, etc., an indication of these items being also shown on the main dial.

As each of the handles is moved a gong is sounded, so that the apparatus cannot be manipulated without the passengers' attention being attracted. When a journey is completed and the fare paid, the driver moves the flag up again (this has to be effected in two stages for a reason to be presently set forth), and the indications on the main dial disappear until the vehicle is again hired. The other handle at the back is for the purpose of winding the clock mechanism.

In addition to the items which affect the passenger, however, the apparatus also indicates the record of a day's work on a side dial, these indications, reading in order from the top downwards in horizontal lines, being as follows:

1. This indicates the number of engagements, for each of which the initial charge has to be accounted for.

2. This indicates all the amounts received above the initial charges.

3. This indicates the totals of all "extras."

4. This indicates the number of miles traveled without a fare.

5. This indicates the number of miles traveled while "engaged" and


FIG. 2.—THE ARON TAXIMETER

therefore while earning a fare.

By means of these indications the earnings of the day and the work done can be readily computed.

Dealing now with the internal mechanism, Fig. 4 indicates diagrammatically, and with all mechanism not actually required for this description omitted, the principal feature of the internal arrangements.

As shown, the "For Hire" indication is exhibited, and with the flag in this position the rocking lever *a* is held out of reach of the eccentric *b* (the eccentric is operated from a running wheel as the vehicle progresses by means of the pin *c*. In this position the spring-controlled brake *d* restrains the movements of the clock mechanism *e;* and the pawl of the "miles vacant" ratchet wheel *f* is in engagement. Consequently, the time mechanism is not recording and the distance mechanism is only operated so far as the "vacant" mileage is concerned. The mileage recording mechanism is operated from the flexible shaft *g* by worm gearing, a pin on the worm wheel *h* moving the latch *i* at each revolution, so as to work out through the link *j* upon the double pawl lever *k*. This latter is operated (by mechanism not shown) so that either the "vacant mileage" ratchet wheel *f* is operated step by step, or the "engaged" mileage ratchet wheel *l* is operated according to whether the flag is up or down.

When the flag is moved to the right, downwardly through an angle of about 120 degrees, and the word "Hired" and the initial fare are shown on the main dial as mentioned, the disc *m* is rotated and this causes the pin *c* to release the lever *a*, while the pin *o* releases the clock brake lever *d* so that the roller *a* on the lower end of the rocking lever *a* comes in contact with the eccentric *b*, thus bringing the fare-recording distance mechanism into action, and at

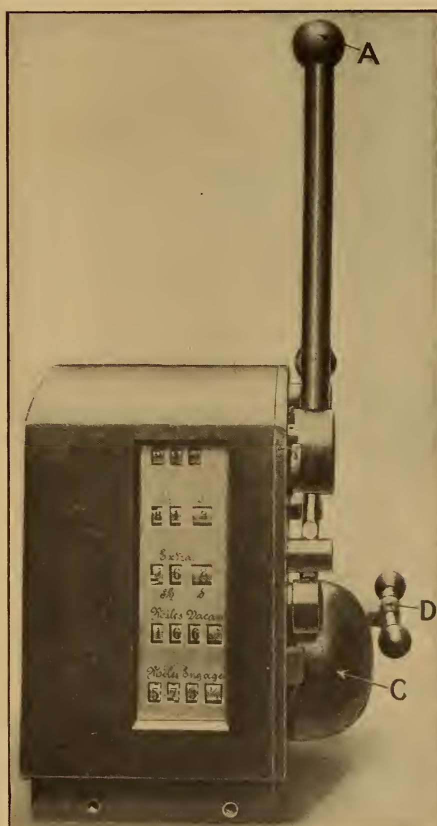



FIG. 3.—THE TAXIMETER REGISTER

the same time allowing the time mechanism to act. The eccentric *b* is actually mounted on the end of the flexible shaft *g* so as to be operated according to the revolutions of the recording vehicle wheel whose circumference forms the unit of distance measurement. At the same time the "engaged" mileage indicator is brought into action as already described.

As the vehicle moves the lever *a* is rocked by the eccentric *b* and its spring return, and the ratchet wheel *p* is operated step by step. The star wheel *q* is geared from *p* and by means of the click *r* it operates the bell-crank *s*, and this in turn operates by one pawl mechanism the ratchet wheel *t* and by another pawl mechanism it operates the ratchet wheel *u* as shown.

A differential mechanism is also employed whereby, so long as the vehicle is standing or is moving at a speed under six miles an hour, the star wheel *q* is operated from the clock mechanism at a rate equivalent to a traveling speed of six miles an hour, but at higher traveling speeds the distance record takes precedence as the effective operating agent, the differential mechanism ensuring that only the faster of the two operating media shall record. The ratchet wheel *t* is the first of a train which computes the charges, while the ratchet *u* relates to a counting device.

When an engagement is completed the flag is moved back half way, stops preventing the full movement, and the word "Charge" is exhibited on the main dial. At this time the clock mechanism is stopped but the distance mechanism still remains in gear, so that while settling up with a passenger the time mechanism does not act although the apparatus is not yet fully out of action. Stops are also arranged so that it is impossible to move the flag down again until it has been returned to the normal disengaged position. After the fare has been paid the flag lever is rocked slightly, this action causing release,

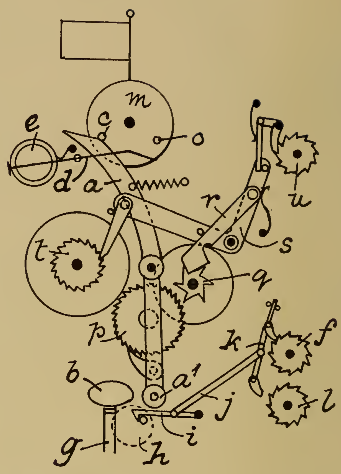



FIG. 4.—MECHANISM OF THE ARON TAXIMETER

and it can then be moved back to the vertical, this movement turning the fare mechanism to zero (except that the pence indication is then eightpence, but this is covered by a shutter), and the "vacant mileage" record is again brought into action.

The illustration is necessarily incomplete and very diagrammatic, so that details of all these special mechanisms are, of course, omitted, but enough has been explained to indicate the main features of the apparatus, and to set forth the principal mechanical characteristics.

In London these taximeters have to be passed upon by three police officials before they are allowed to be placed in service, and they have to be periodically tested. It is not claimed that the record is infallibly accurate, but as a rule the advantage is slightly in favour of the passenger, and practice has shown these taximeters to be more than sufficiently accurate for all practical purposes.

In case a driver finds that his apparatus is out of order, a stock of approved taximeters is usually kept at the depots for replacement purposes.

These apparatuses are constructed very lightly, considering the amount of mechanism they necessarily contain, and aluminium is extensively employed.

# AIR COMPRESSORS

By C. S. Vesey Brown, M. Inst. C. E.

THE application of compressed air to industrial use has been treated in comprehensive articles contributed to CASSIER'S MAGAZINE from time to time during the past few years.

In only a few instances is there any description given in these articles of the machine used to supply the compressed air, and, as there are a large number of compressors on the market, it is thought that a general review of some of the prominent types may be of interest.

The theoretical principles involved in the compression of air or any gas are well known, and this article will treat only of the practical application of certain types of machines to arrive at the highest efficiency in the production of compressed air. Nor is it proposed to include any description of "blowing" engines, which supply air at low pressure for blast furnaces, etc., but to only consider those machines which deliver air at pressures from 60 to 1,000 pounds or more for use in pneumatic tools, torpedoes, etc.

A point to be observed by users of compressed air is the necessity of determining the size of the compressor in relation to the work it has to do. The relationship between cubic feet of free air per minute, final pressure at the "point of use," and the pneumatic tool are not the same for all industrial uses, so that a machine which compresses air for one purpose is probably inefficient when applied to another use; and again, in many cases it is essential to combine the compressor with a "receiver" to either store the compressed air or act as a buffer against the shocks likely to arise in the use of the pneumatic tool, etc. All these points have to be taken into consideration when deciding on any particular type of compressor.

The principal features to be observed in any compressor to arrive at the best results are:

1. Good workmanship and construction, to allow the free radiation of the heat produced in the compressor either with or without water circulation;

2. To obtain as much use as possible out of the cubic contents of the cylinder when filled with free air with as uniform a torque as possible, and

3. To ensure that the inlet and outlet valves open and close at the right moment, and stay open or closed as long as possible during each stroke without wire-drawing of the air, etc.

An imperfectly designed or adjusted valve system will reduce the efficiency of a compressor to such a degree as to make it almost useless and extremely wasteful; for instance, the effect of a thin stream of air admitted through a wire-drawn passage on to the heated surface of the compressed cylinder will reduce the weight of air, and consequently the useful horse-power to be obtained from the compressed air. The valve question in relation to volumetric efficiency has received a great deal of

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"Energy transmitted by Compressed Air," by C. A. Hague, Vol. 10, page 448.
"Compressed Air in Mining," by E. A. Bix, Vol. 14, page 66.
"Compressed Air on Warships," by Eng. T. W. Kirkland, U. S. N., Vol. 15.
"Compressed Air in Machine Shops," by W. S. Saunders, Vol. 23, page 3.
"Compressed Air on Railways," by C. B. Hodges, Vol. 28, page 466.
"Rateau's Turbo Compressor," Vol. 32, page 372.
"Some Recent Advances in the Application of Compressed Air," by W. L. Saunders, Vol. 31, page 125.

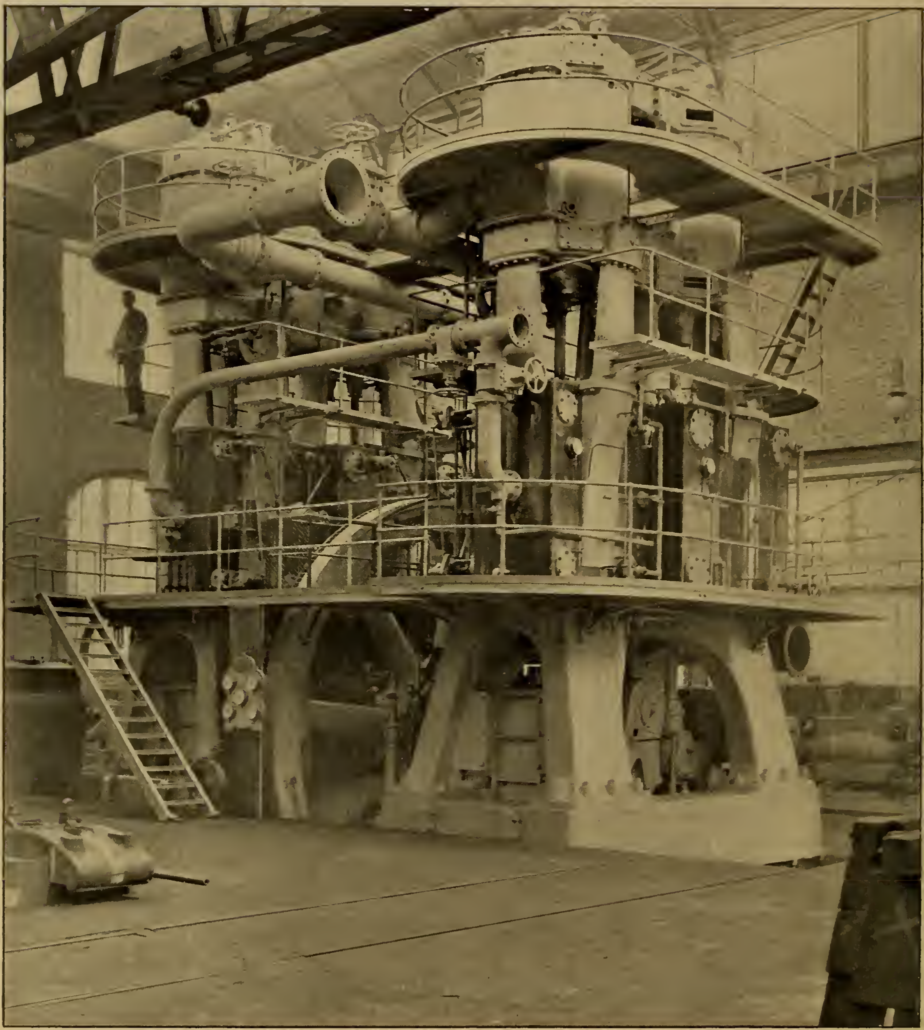

FIG. 1.—LARGE VERTICAL RIEDLER AIR COMPRESSOR. CAPACITY 30,000 CUBIC FEET PER MINUTE AT 50 REVOLUTIONS. FRASER & CHALMERS, LTD., LONDON AND ERITH

attention from makers of compressors, and there is as much diversity of practice in the design, working and adjustment of the valve gear as there is in the shape of the compressor itself.

Broadly speaking, air compressors are divided into four classes:

1. Slow-speed, double-acting type, with mechanically-moved or spring-loaded valves, or both.

2. High-speed single and double-acting type, with or without mechanically-moved or spring-loaded valves.

3. Rotary compressors.

4. Semi-reciprocating type, in which the rotary movement is translated into a reciprocating action, or *vice versa*.

The first type is used entirely in large installations where compressed air is conveyed to a number of machines scattered in different parts of the works or mine. A colliery working gaseous coal and scattered drills in metalliferous mines are the best

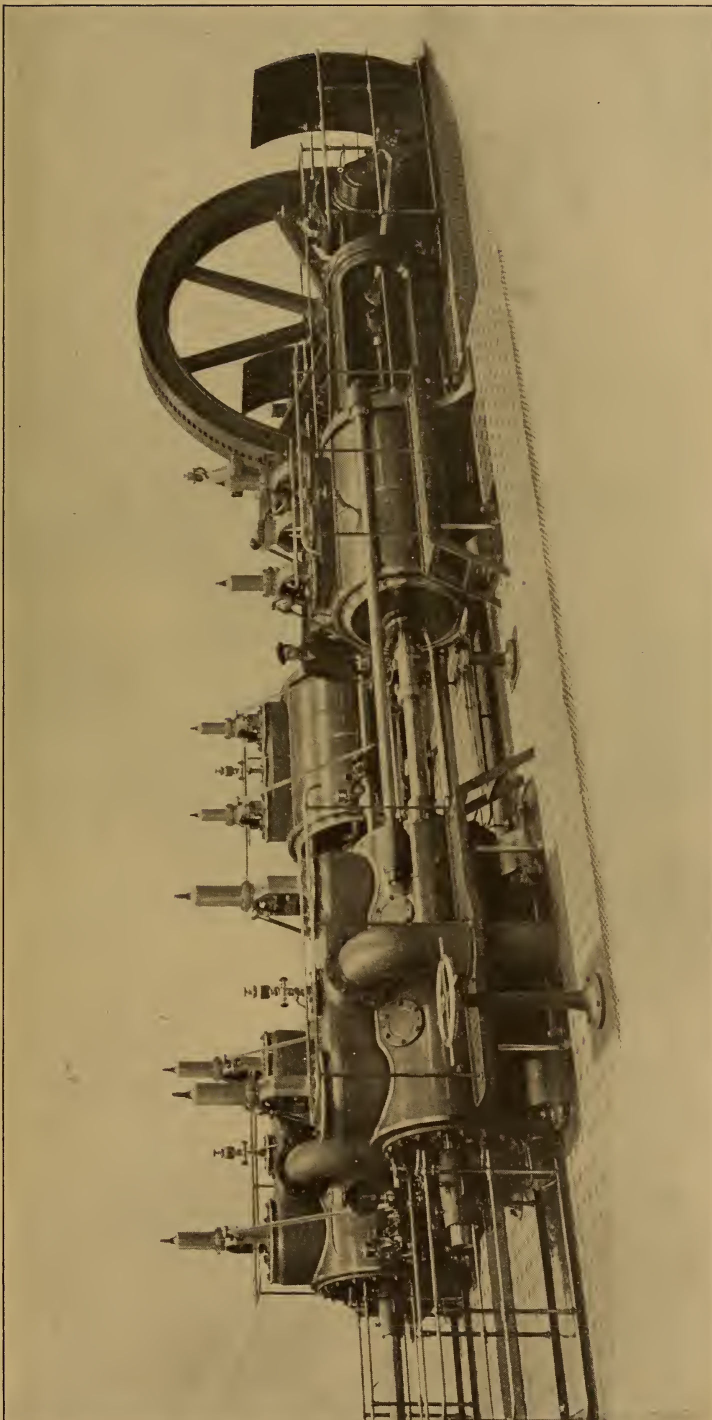

FIG. 2.—HORIZONTAL AIR COMPRESSOR, CAPACITY 103 CUBIC METRES PER MINUTE, 60 REVOLUTIONS PER MINUTE. SULZER BROTHERS, WINTERTHUR, SWITZERLAND

instances of this type of compressor, dealing as it does with large quantities of air per minute; such a machine is installed "at bank" and is driven directly by a compound or triple-expansion engine. The air is conveyed down the pit shaft and then distributed to the haulage gears, pumps, coal cutters, drills, etc. Typical illustrations are shown in Figs. 1 and 2. The first is a vertical type of compressor, specially adapted for use where floor space is of value. It consists of an ordinary vertical type steam engine, fitted with Corliss valve gear to ensure a high economy in steam consumption, and to enable rapid fluctuation in the load to be dealt with under a comparatively constant speed. The air cylinders are mounted in tandem above the steam cylinders, separated from the latter by a distance piece to enable the glands to be packed, etc. The distance pieces are cast in halves, and when removed (the air cylinders being previously supported by ordinary bottle jacks) the top cover of the steam cylinder can be removed and the pistons examined and removed if necessary. Each air cylinder contains one suction and one delivery valve operated on the Riedler principle. The usual speed for this combination is from 95 to 65 r. p. m. for sizes from 2,100 cubic feet of free air per minute up to 13,250 cubic feet, at 80 pounds pressure.

The second compressor, shown in Fig. 2, is driven by a slow-speed, cross-compound engine; with extended piston rods carrying the air pistons, and a tail rod through to the rear of the compressor, describes in a general manner this type of machine. Fig. 4 shows a section of the steam-valve gear on the engine driving the compressor illustrated in Fig. 2. The drawing shows clearly the arrangement of the valves and their driving mechanism, and no further explanation is needed.

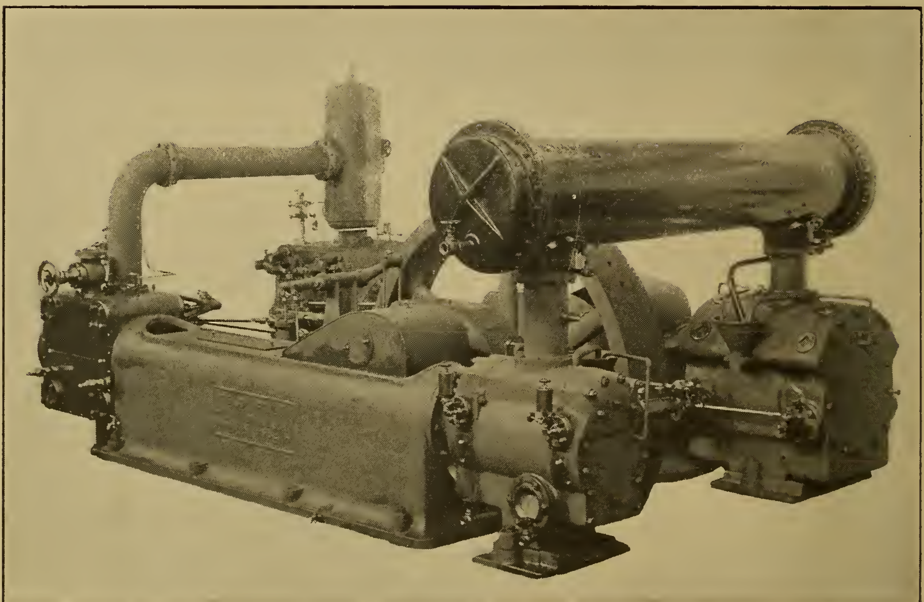

FIG. 3.—VIEW OF AIR END OF INGERSOLL-RAND IMPERIAL-TYPE CORLISS AIR COMPRESSOR

Many makers use direct spring-loaded valves without the assistance of mechanical movement.

To ensure complete cut off of the air at the right moment, and in addition some degree of silence, it is

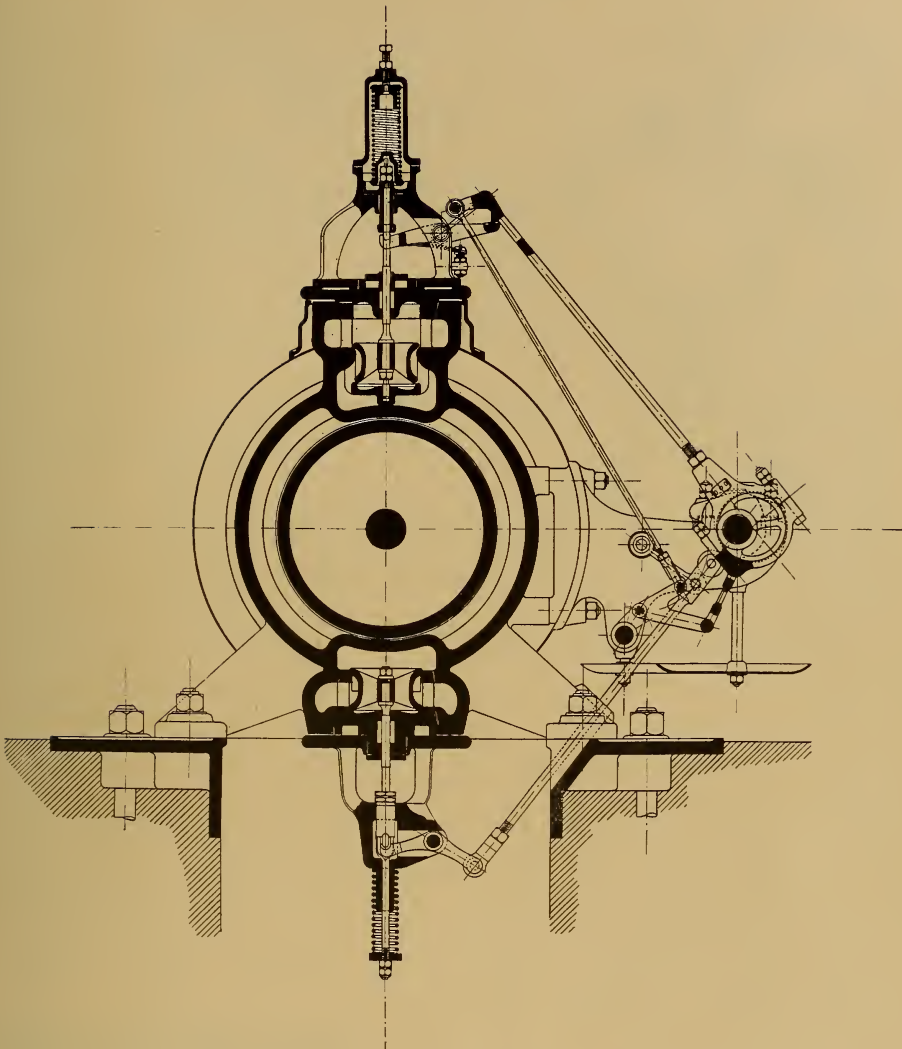

FIG. 4.—SECTION OF HORIZONTAL COMPRESSOR SHOWING CORLISS TYPE STEAM VALVE GEAR. SULZER BROTHERS, WINTERTHUR, SWITZERLAND

necessary that spring-loaded valves should reseat themselves with accuracy and speed. The Worthington poppet valves shown in Fig. 5 depend entirely on the spring and guides for these qualities, but it is found that a certain amount of hammering takes place, and a special mixture of bronze is used for the seats, the valves being made of high-grade steel. A variation on this valve gear is shown in Fig. 7, illustrating the Cincinnati valve extensively adopted for medium speeds by the Worthington Company. It will be seen that the gear combines a mechanically moved Corliss type of valve, which, at the end of each discharge stroke, traps a small amount of air under the poppet spring-loaded valves, and so lessens the shock on re-seating. The makers claim other advantages in construction and maintenance. An ingenious spring valve

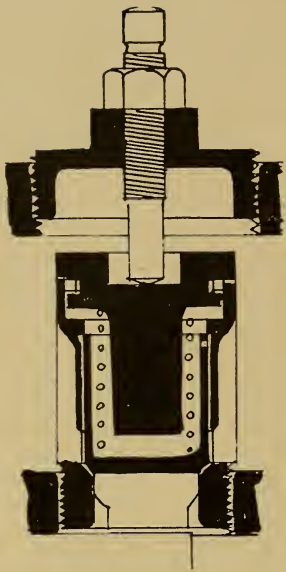

FIG. 5.—SPRING-LOADED POPPET VALVE. WORTHINGTON PUMP COMPANY, LTD.

used by Messrs. Fraser & Chalmers, Ltd., called the "Gutermuth" valve, is illustrated in Fig. 8. This valve, which has the appearance of a snail in section, is equally suitable for air or liquids. The valve is made out of sheet metal, which may be varied in width, dependent on the amount of air or liquid which has to pass the port covered by the valve. The sheet is then coiled and slipped on to its spindle and held in place by clamps, the sheet being cut conical shape to allow the clamps to so hold the coiled sheet without fouling the end of the valve. The valve is really something like a "hair spring" of a watch—it cannot be overstrained by any length of *legitimate* use. Its action when closing is like the unwinding of the spring, as will be seen from the illustration, and the makers claim that it is quite silent. The simplicity of this valve has much to recommend it, especially when running at a high speed, and it has the additional advantage that both suction and delivery valves can be of the same size, and are thus interchangeable.

Fig. 9 shows the well-known Riedler valve gear, which has been largely used in horizontal compressors. The operation is of a simple character, as will be seen from the illustration; the inlet and outlet valves operate as follows: Where the air is expelled from the cylinder or is in excess of the outside pressure, as the case may be, the valves open automatically to a "full open" position and remain so until nearly the end of the stroke, when a fork, actuated from a way shaft off the main shaft or by any convenient rocking motion or wrist plate, closes the valves, pressing on the points *aa* or *bb* as required. This closing action is timed, of course, with the position of the piston, and can be adjusted while the machine is in operation.

The Matthewson valve gear shown as fitted to a compressor in Fig. 12 is applicable to high or medium-speed compressors. They are made from specially light steel stampings, the inlet valves being ground to the seat surface whilst held by a magnetic chuck, and the delivery valves are held tight by a specially closed coil spring which prevents shock on closing.

Fig. 14 illustrates a piston type of valve gear supplemented by check valves. The illustration explains the action of the main valves, the smaller

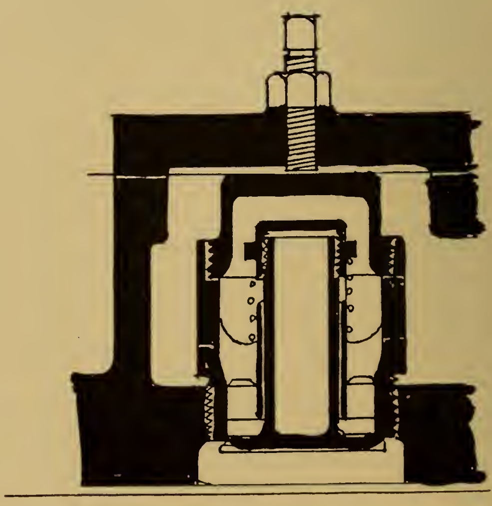

FIG. 6.—SPRING-LOADED POPPET VALVE. WORTHINGTON PUMP COMPANY, LTD.

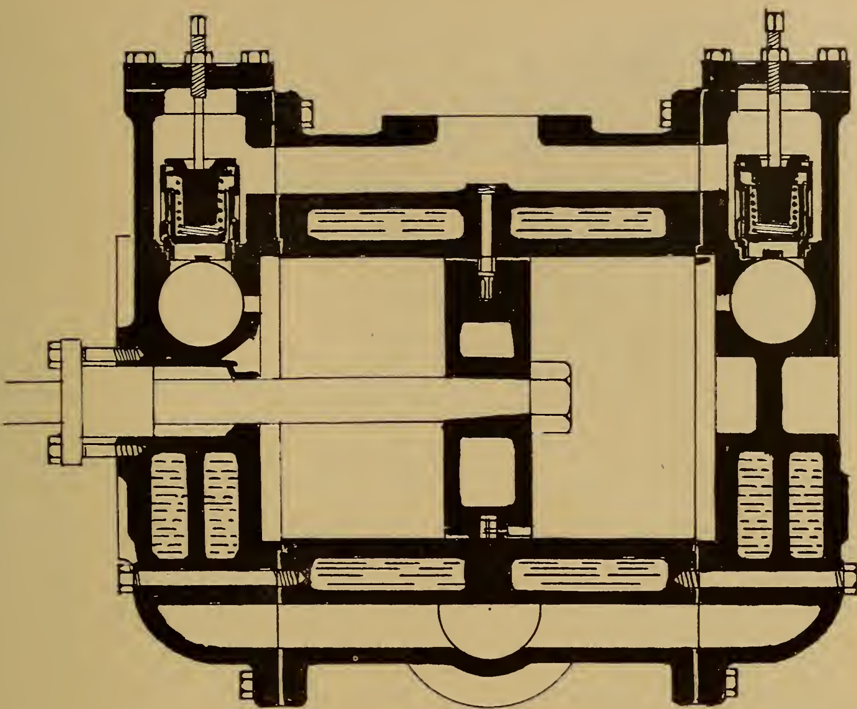

FIG. 7.—CINCINNATI VALVE GEAR. WORTHINGTON PUMP COMPANY, LTD.

check valves being used only to prevent the return of compressed air to the cylinder, and as they are in equilibrium can therefore close quietly at any speed. The construction of the machine admits of the whole piston-valve gear being withdrawn separately to enable examination of the check valves as may be required.

There are many other types of valve gear used, but the above show the prominent types in use for low and medium-speed compressors.

The heavy first cost of providing slow-speed compressors and the very doubtful efficiency results as between prime mover and "point of use" of these large sizes have led to a number of high-speed machines being constructed, which can be driven by either a high-speed steam engine or gas engine or an electric motor. As a general rule, this type of compressor does not exceed 120 to 150 horse-power, and owing to its size and weight is capable of being placed


FIG. 8.—GUTERMUTH VALVE. FRASER & CHALMERS, LTD., LONDON AND ERITH

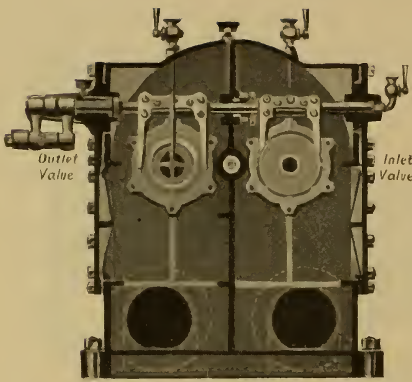


FIG. 9.—RIEDLER VALVE GEAR

comparatively close to the work it is called upon to perform, and thus increase the efficiency of the system.

These machines come under the second class and are divided in gen-

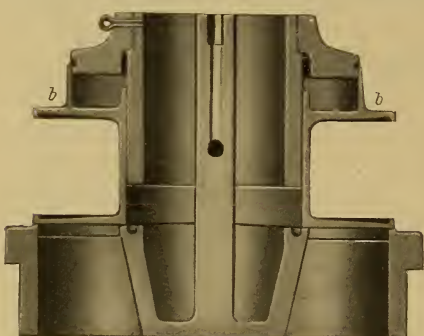


FIG. 10.—RIEDLER OUTLET VALVE

eral into two sections, viz.: those which are driven direct by either steam or gas engine or electric motor, and those which require one or more reductions from the speed of the

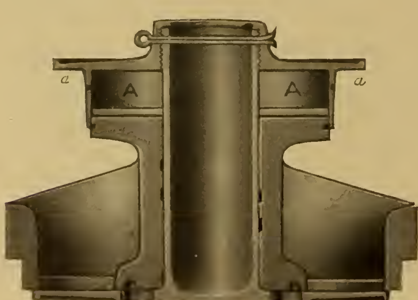


FIG. 11.—RIEDLER INLET VALVE

prime mover. A good example of the latter class is seen in Fig. 17, which shows a belt-driven compressor running at 130 to 180 r. p. m. This machine is double acting and may be driven by belt from either a steam or gas engine countershafting or electric motor. Another pattern is shown in Fig. 16, which shows a sectional plan of a "Koster" two-stage compressor fitted with Koster me-

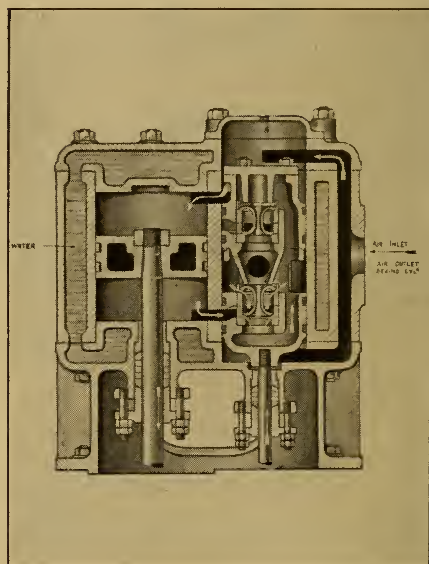

FIG. 12.—MATTHEWSON VALVE GEAR FOR HIGH-SPEED COMPOUND COMPRESSOR. TILGHMAN'S PATENT SAND BLAST COMPANY, LTD., MANCHESTER

chanically-operated inlet valves and combined mechanically-operated and spring-loaded delivery valves. Fig. 18 shows a steam-driven two-stage compressor by the same makers.

Another type of fairly high-speed compressor is shown in Figs. 19 and 22. The inlet valves are mechanically operated, of the Corliss type, and the delivery valves are of the usual spring-loaded pattern. The Franklin compressor is as well known in the United States as in Europe, and is constructed on sound mechanical lines. The machine illustrated is the result of much experience, and represents a typical steam-driven two-

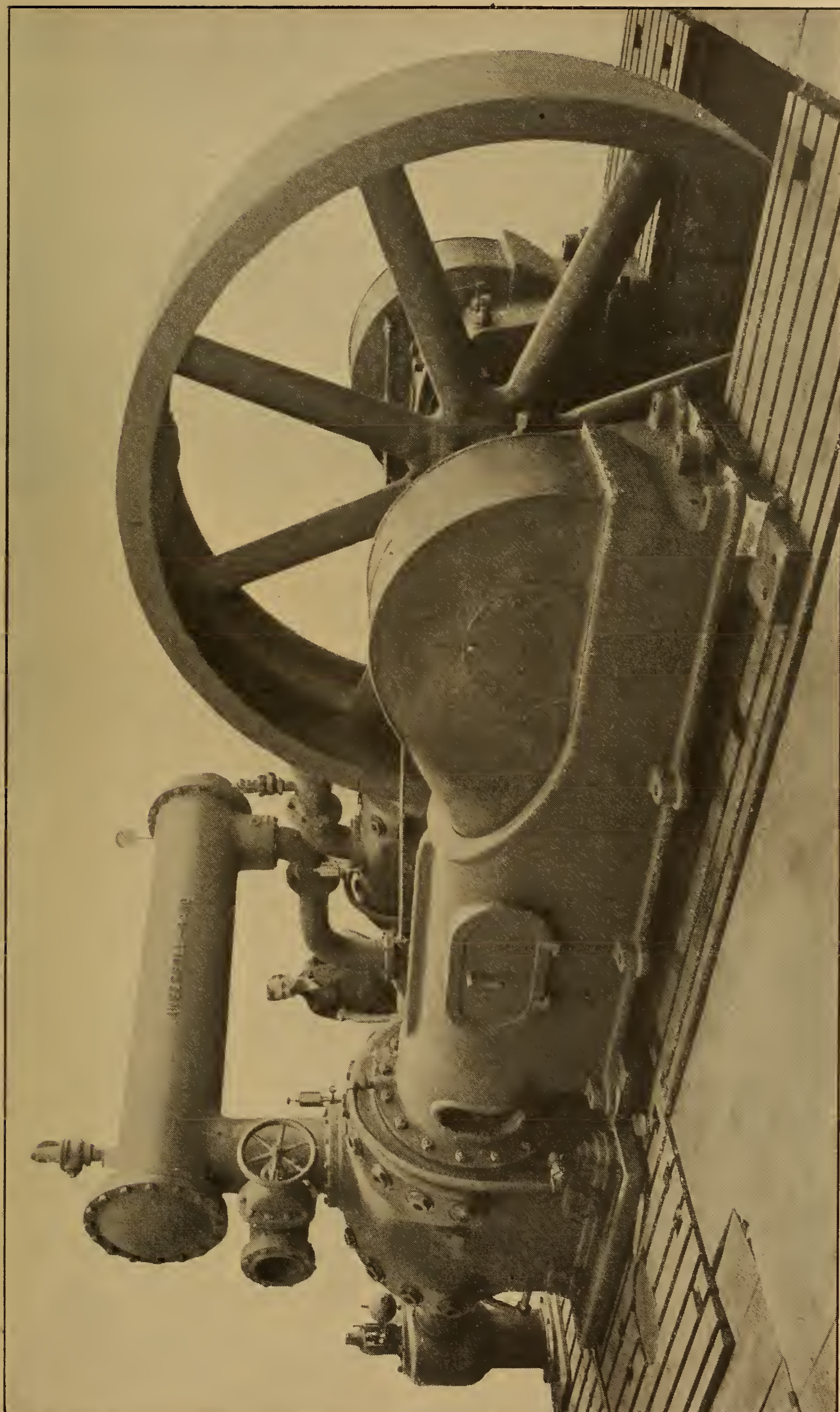

FIG. 13.—BELT-DRIVEN AIR COMPRESSOR WITH OVERHEAD INTERCOOLER. INGERSOLL-RAND COMPANY, NEW YORK

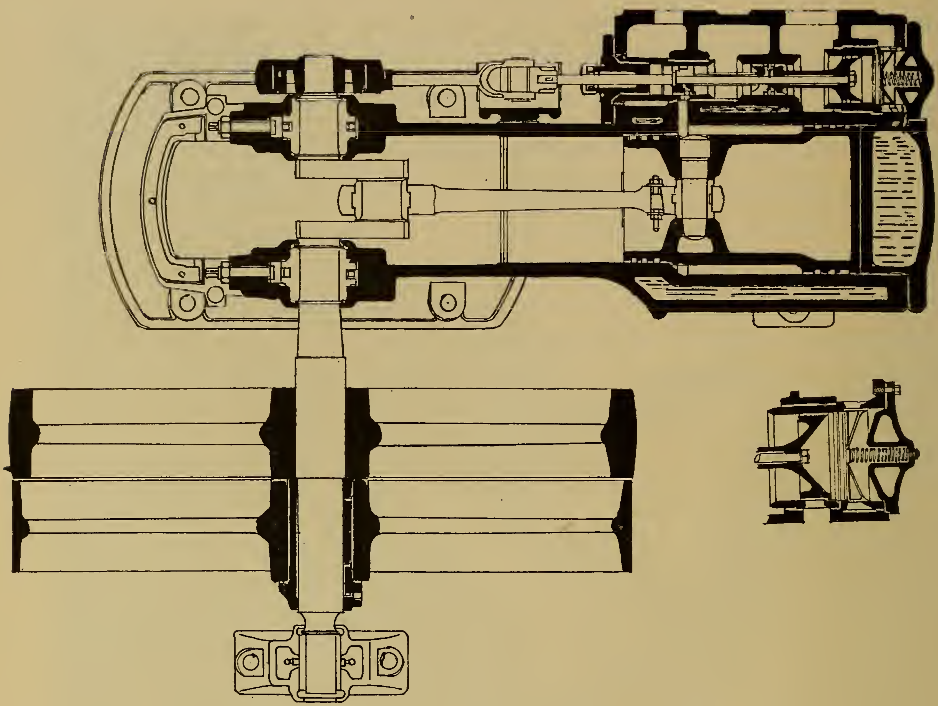

FIG. 16.—SECTIONAL PLAN OF BELT-DRIVEN TWO-STAGE COMPRESSOR WITH KOSTER VALVE GEAR. W. H. BAILEY & CO., LTD., MANCHESTER

stage compressor for 100 to 125 pounds pressure. The valve seats and stems are separated from the air cylinders, and can be removed and replaced without the necessity of removing the cylinder cover. The same compressor is made with either poppet spring-loaded valves or mechanically-moved intake valves actuated in the usual manner by eccentrics off the main shaft, and by arranging these eccentrics to be independent of the steam valve eccentrics, the adjustment of air valves and the opening and closing of the ports can be done to a nicety.

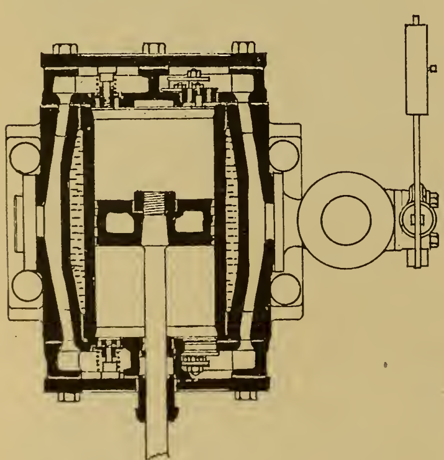

FIG. 14.—PISTON VALVE GEAR WITH SUPPLEMENTARY CHECK VALVES. TILGHMAN'S PATENT SAND BLAST COMPANY, LTD., BROADHEATH, NEAR MANCHESTER

The governing of the air pressure or "unloading" (as the makers term it) is controlled by the device shown in Fig. 21. The operation is effected

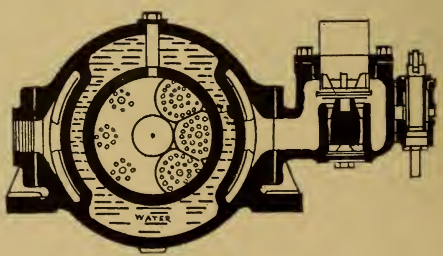


FIG. 15.—SECTION OF PISTON VALVE GEAR

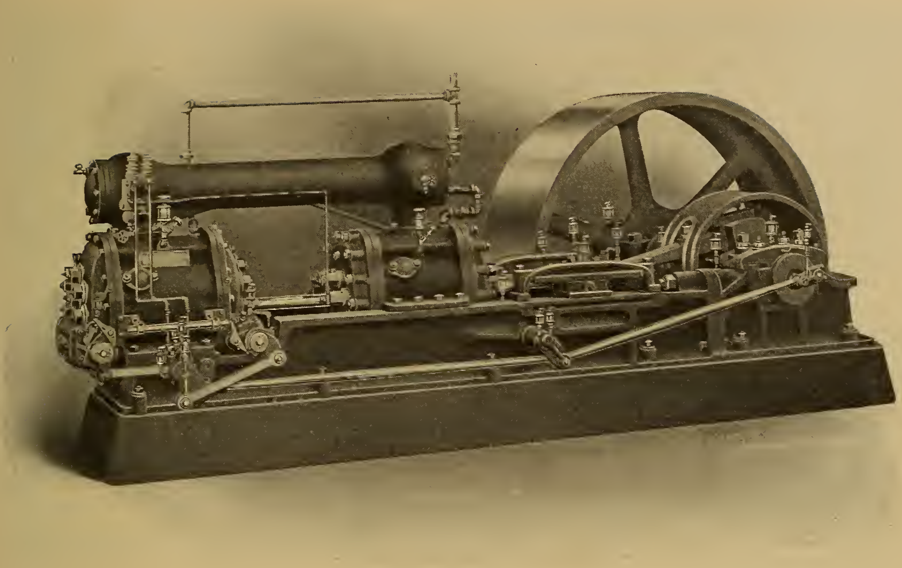

FIG. 16.—POWER-DRIVEN AIR COMPRESSOR SHOWING ARRANGEMENT OF UNLOADING DEVICE. THE NORWALK IRON WORKS COMPANY, SOUTH NORWALK, CONN.

by the gradual closing of the air passage on the inlet when the desired pressure is reached in the receiver or compressor.

Another type of governor is that known as the "Whitmore," made and used by Fraser & Chalmers, Ltd., Fig. 23. It is a combination of the ordinary fly-ball governor for regulating the speed and a spring-loaded governor for regulating the air intake. The speed governor has two springs, as will be seen—that marked *A* allows the governor sleeve *B* to rise about ⅜ of an inch without compressing the spring. As the speed

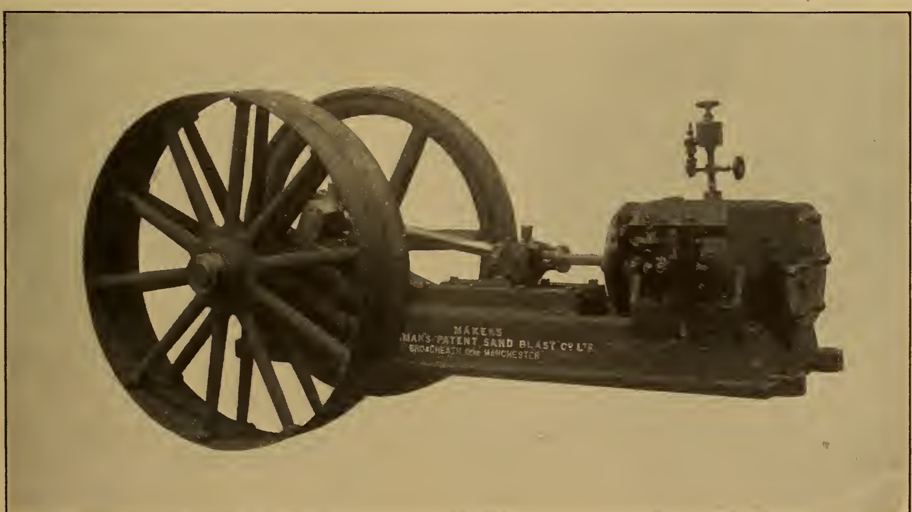


FIG. 17.—BELT-DRIVEN COMPRESSOR. TILGHMAN'S PATENT SAND BLAST COMPANY, BROADHEATH, NEAR MANCHESTER

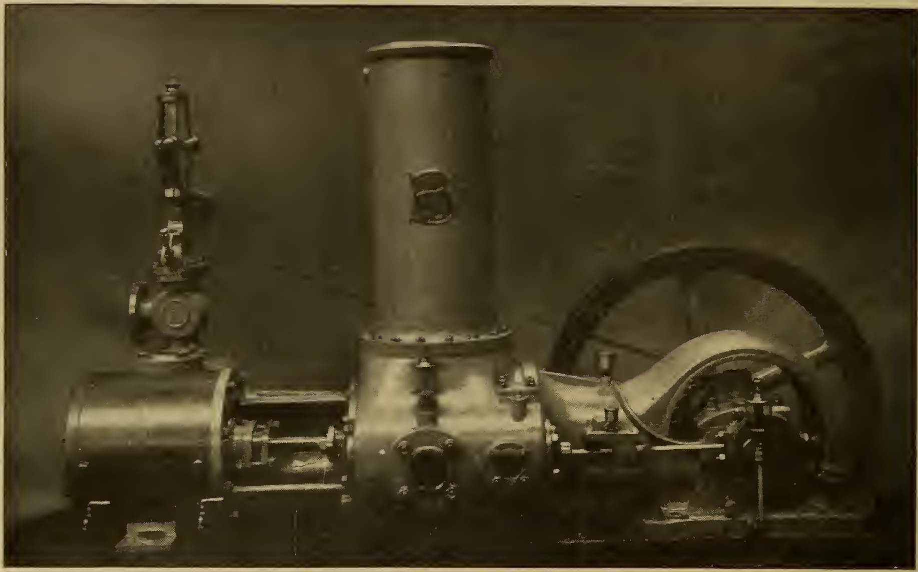

FIG. 18.—STEAM-DRIVEN TWO-STAGE KOSTER COMPRESSOR. W. H. BAILEY & CO., LTD., MANCHESTER

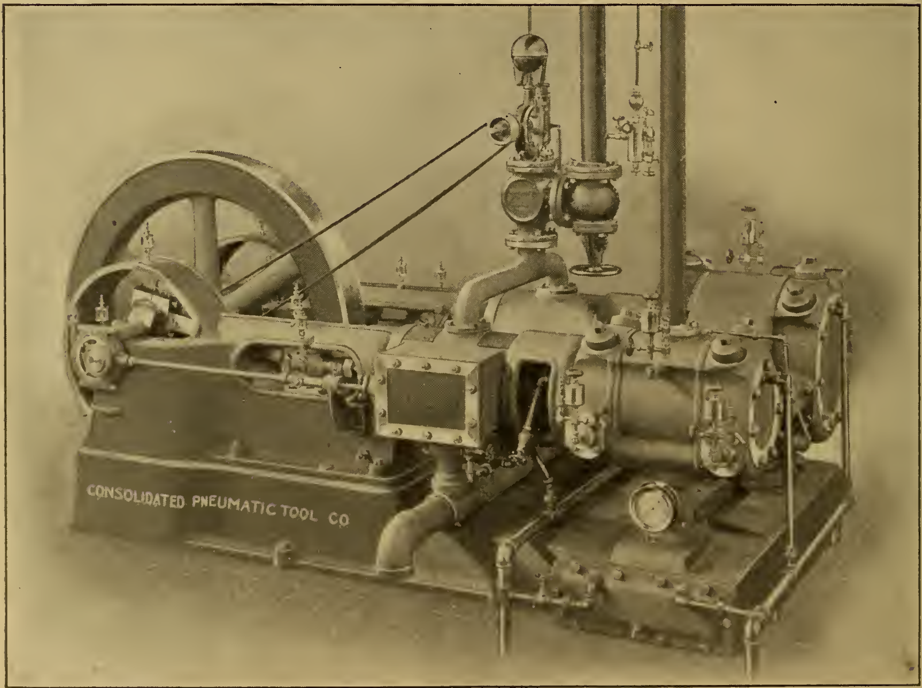


FIG. 19.—FRANKLIN COMPRESSOR. CONSOLIDATED PNEUMATIC TOOL COMPANY, LTD., LONDON, AND FRASERBURGH, SCOTLAND

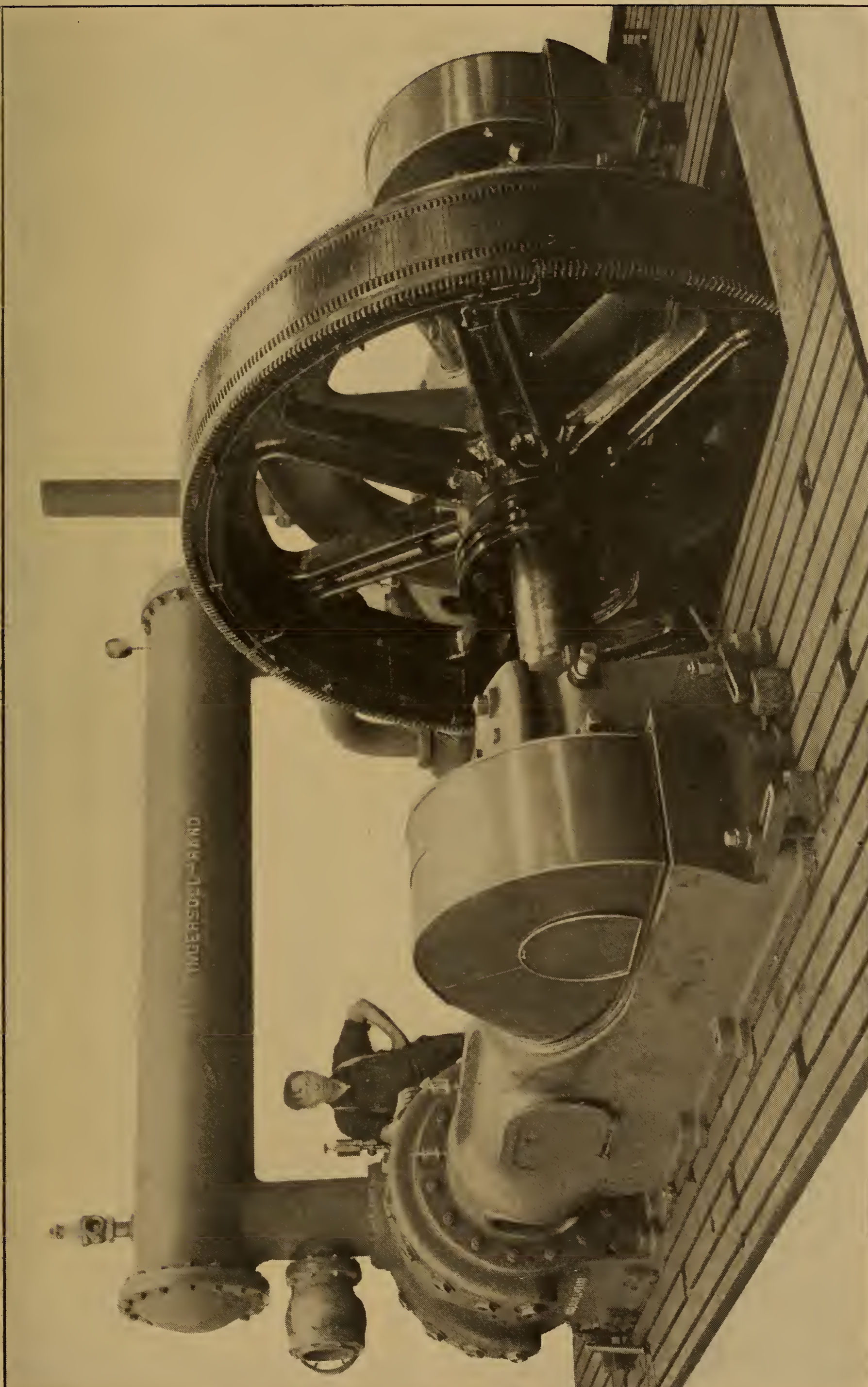


FIG. 20.—ELECTRICALLY-DRIVEN AIR COMPRESSOR, WITH 300-HORSE-POWER THREE-PHASE INDUCTION MOTOR, 145 REVOLUTIONS PER MINUTE.
INGERSOLL-RAND COMPANY, NEW YORK

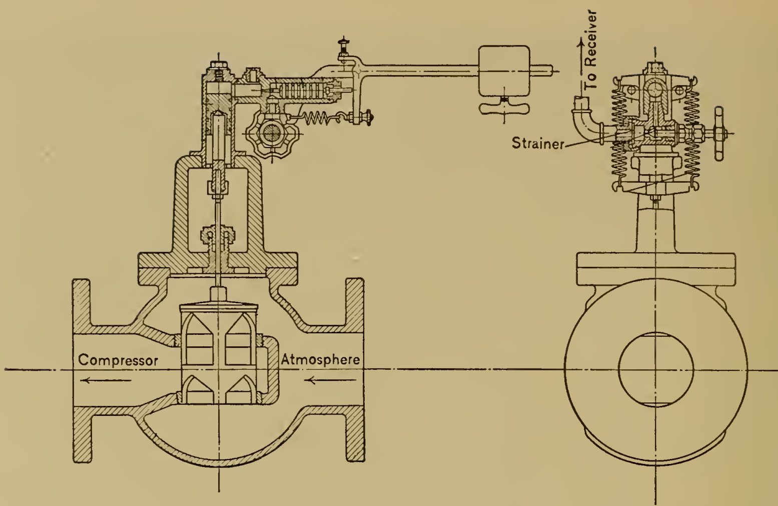


FIG. 21.—FRANKLIN UNLOADER. CONSOLIDATED PNEUMATIC TOOL COMPANY, LONDON AND FRASERBURGH

increases, this spring is compressed until the travel of the governor sleeve reaches about 2⅜ inches. The top spring marked *C* comes into action as soon as *A* is compressed to its limit, and the speed exceeds a predetermined value, say 5 per cent. The compressor governor has a double safeguard against excessive air. It will be seen that spring *D* is connected to a plunger *E*, and through a series of levers to the fork on sleeve *B* and the other end of the lever to the cut-off gear on the compressor intake or delivery; so that as the speed rises or falls the movement of the lever controls the air supply. The movement of the plunger *E* is also controlled by the variation in the position of the plunger *F* in its relation to the pressure of air. It will be seen on referring to the figure that the weight on plunger *F* is connected to the pin joining *D* and *E* by a lever multiplying the movement several times, and that a small movement of *D* and *E* gives a large movement of *F*. Oil is forced through from one end to the other, or *vice versa*, as the plunger *F* rises or falls, and this prevents any "hunting" action taking place.

The single-acting, high-speed type of compressor has received considerable attention at the hands of several makers. Summers & Scott, Ltd. (Fig. 24), make a machine which has a peculiar suction-valve gear. The air supply is controlled first by the trunk piston, which admits air through the cylinder casing into the general body of the machine; the air is then drawn to the top of the piston into the compression chamber through a spring-loaded suction valve, the opening movement being actuated by a cam on an extension of the connecting rod. This cam presses against the hardened steel point of the valve and opens the suction port, and as the connecting rod alters its position (due to rotation of the shaft) the cam releases the valve slowly, the spring pressure ensuring complete seating of the valve. At the top of each stroke the suction and delivery valves are just in contact when the latter is open, and as the return stroke takes place the delivery valve is lowered on to its seat, following the suction valve. The clearance in the cylinder is very small, and a good volumetric efficiency is obtained. The adjustment of the cam for wear is made by altering the strap, on which the cam is formed, by moving the

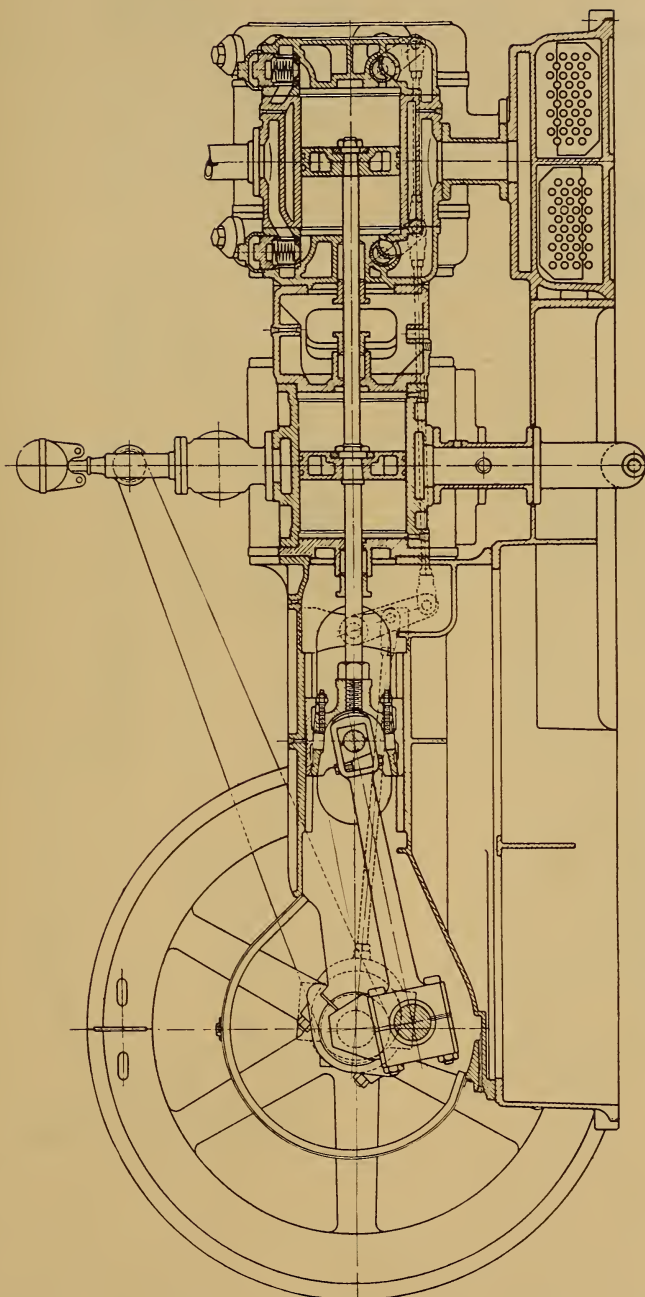

FIG. 22.—FRANKLIN TWO-STAGE COMPRESSOR, SHOWING ARRANGEMENT OF MECHANICALLY-ACTUATED INTAKE VALVES.
CONSOLIDATED PNEUMATIC TOOL COMPANY, LTD., LONDON AND FRASERBURGH

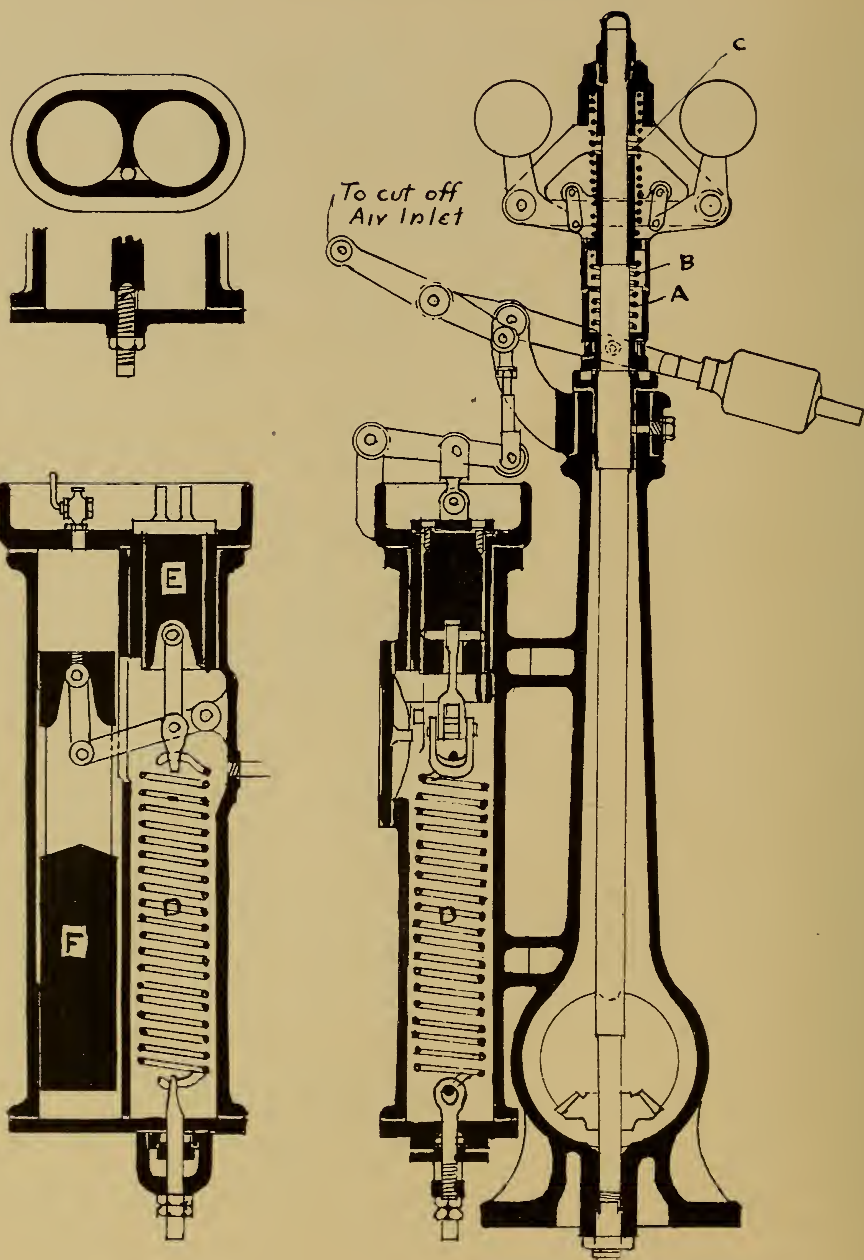


FIG. 23.—SECTION OF WHITMORE COMBINED STEAM AND AIR GOVERNOR. FRASER & CHALMERS, LTD., LONDON AND ERITH

bolts holding same to the connecting rod. An oil separator is required on this machine to remove any oil which may be taken in by the suction valve from the trunk chamber. Heat radiation is provided for by "ribbing" the outside of the cylinder casing of the smaller sizes, and blowing air on to them from a small fan run off the crankshaft. The larger sizes are

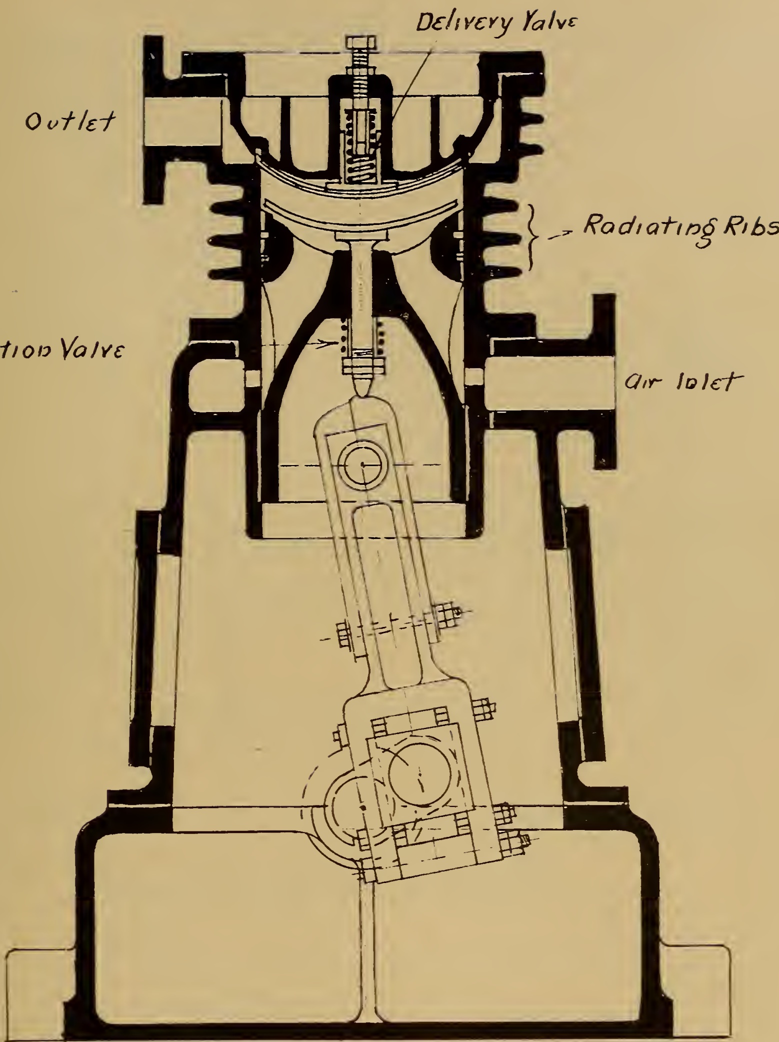


FIG. 24.—SECTIONAL VIEW OF SCOTT SINGLE-ACTING AIR COMPRESSOR. SUMMERS & SCOTT, LTD., GLOUCESTER

sprayed with water and air without any return water pipe. By placing two or three of these compressors side by side, the machines can be made to deliver up to 600 cubic feet of free air per minute.

Reavell's type of single-acting air compressor has been developed to a remarkable degree. Commencing in quite a humble manner about ten years ago with a single stage compressor up to 50-60 pounds, the machine has now been constructed and improved to give 1,000 pounds pressure with a three-stage compression. This necessitates an intercooling arrangement between each compressor. The section shown in Fig. 28 shows the compact arrangement involved in this type of machine. The air inlet is in each case controlled by the piston, that is to say, there are no suction valves, the air being taken in through an open port-hole without any valves, and is admitted to the top of each piston through a port-

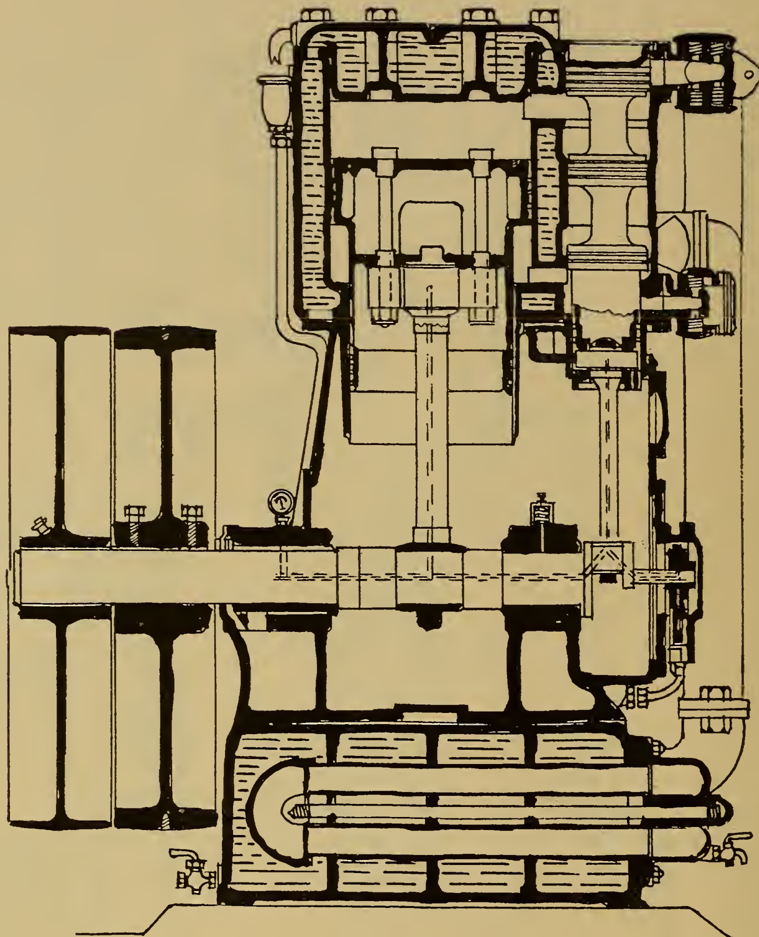

FIG. 25.—SECTIONAL VIEW OF TWO-STAGE SINGLE-ACTING SENTINEL COMPRESSOR. ALLEY & MC LELLAN, LTD., GLASGOW

hole which coincides with a smaller port on the top of each connecting rod, and at the end of each stroke the piston overruns the ports in the cylinder and makes a direct communication between the cylinder and the annular space between the cylinder walls and the casing encircling the machine. The makers claim that this suction arrangement gives 5 per cent. better volumetric efficiency than those compressors fitted with spring-loaded valves.

The delivery valves are fitted to the cover of each cylinder. They are made of steel with a spring to reseat them promptly and quietly. Fig. 30 shows the simplicity of the construction of the shaft, connecting rods and pistons. The sides of the piston guides are cut away to allow each separate connecting rod to be removed for examination, etc. Where large quantities of air are required, and space is a consideration, and with electric power available, the machines are made double ended, i. e., a compressor is fixed on each end of the motor shaft. (See Fig. 26.) The cooling arrangements for this type of compressor are extremely simple, as its construction enables advantage to be

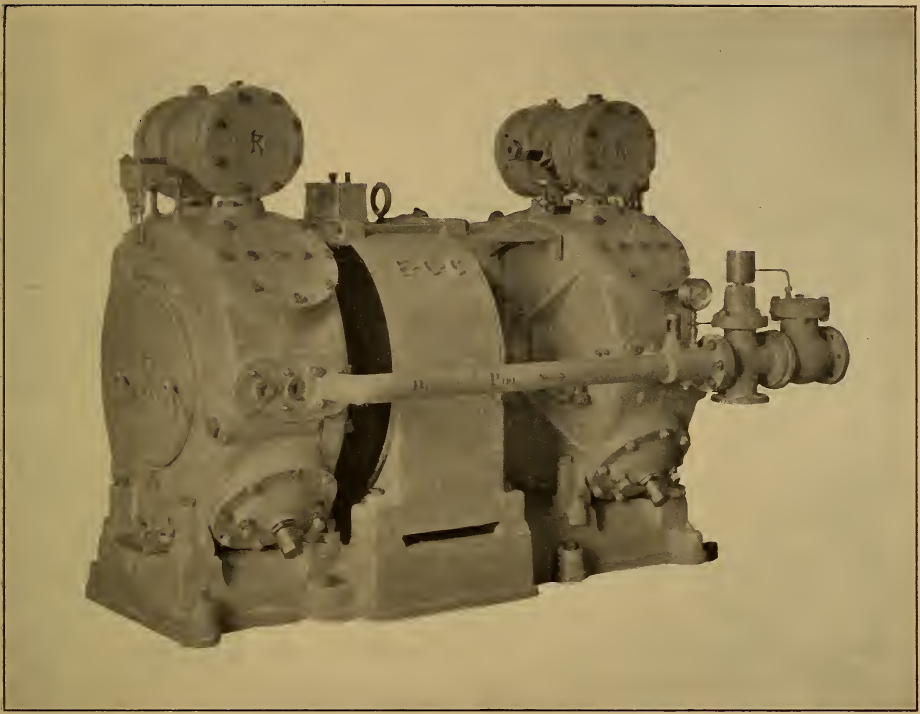

FIG. 26.—STANDARD DOUBLE-ENDED, MOTOR-DRIVEN, SINGLE-ACTING COMPRESSOR. REAVELL & CO., LTD., IPSWICH

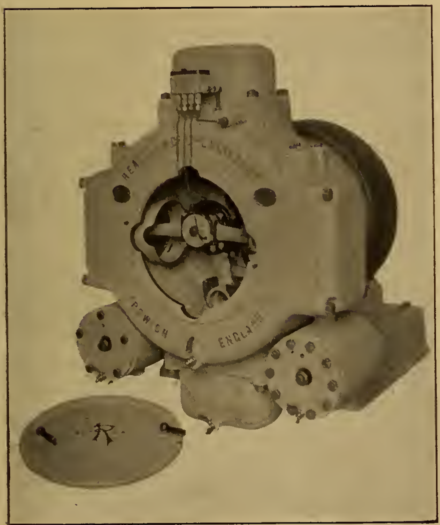

FIG. 27.—STANDARD THREE-STAGE COMPRESSOR FOR 1,000 POUNDS PRESSURE. REAVELL & CO., LTD., IPSWICH

taken of the annular space between the outside of the cylinder and the casing surrounding it.

The Sentinel type of high-speed compressor has a peculiar arrangement of pistons. In all but the smallest sizes, the machine is made as a two-stage compressor. The sectional view in Fig. 29 is typical of the construction. The valve gear is of the piston type for the suction and delivery, with supplemental check valves on the delivery side. The principle adopted in this compressor is to compress the air to one stage, pass same through a cooler situated in the base of the machine, and complete the compression in the high-pressure cylinder, which, as is seen in the illustration, is formed out of the difference in diameter between the low-pressure cylinder and the trunk of the low-pressure piston. The valve gear consists of a triple-ported piston valve, arranged so as to pass the

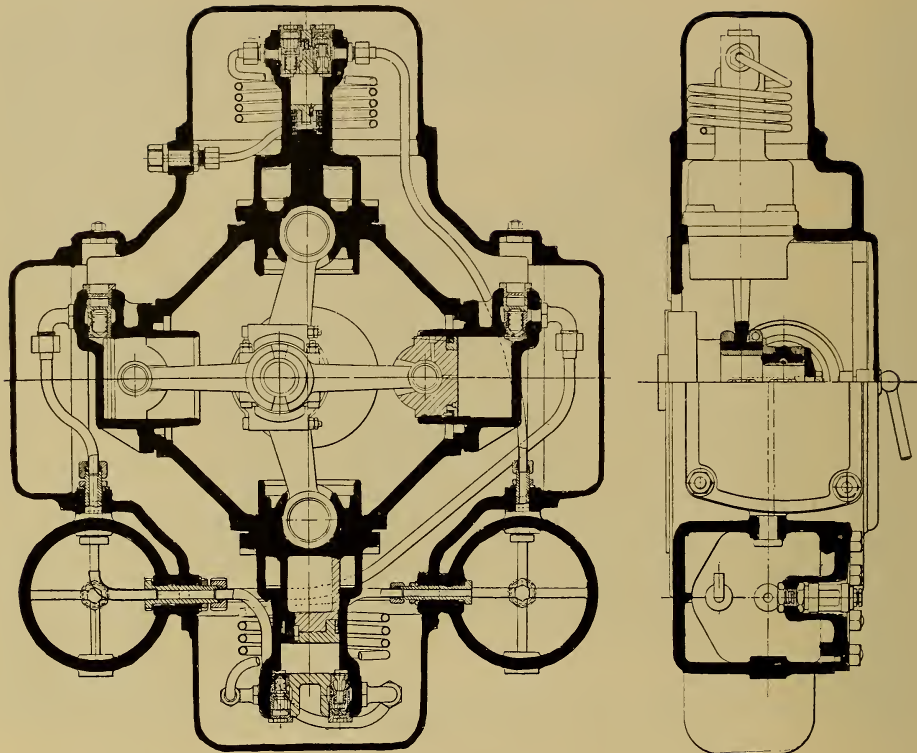

FIG. 28.—SECTION OF THREE-STAGE COMPRESSOR FOR 1,000 POUNDS PRESSURE.
REAVELL & CO., LTD., IPSWICH

air at its different stages from the low-pressure cylinder to the cooler and back to the high-pressure cylinder, then to the receiver. Forced lubrication and water cooling are both adopted as a means to reduce the mechanical friction and increase the "heat efficiency" of the machine.

A type of compressor in general use in the British navy is that shown in Fig. 33. This is a vertical direct-acting compressor of the double-acting type. The air cylinder is bolted direct to the trunk of the machine and the steam cylinder or cylinders, as the case may be, are above. As the examination of the steam piston valves, etc., is of more frequent occurrence than that of the air cylinder, etc., this mode of construction is of advantage in giving the least trouble to effect periodical examination of the steam end of the machine.

A recent development of a high-

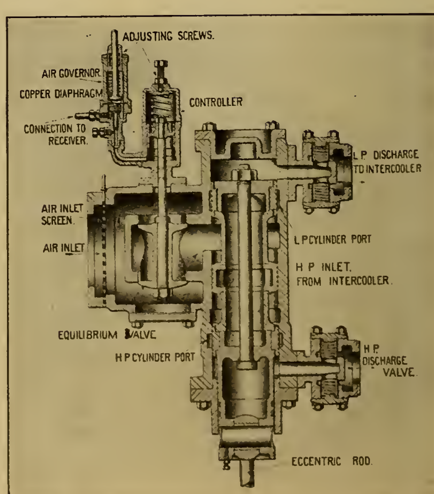


FIG. 29.—SECTIONAL VIEW OF SENTINEL AIR GOVERNOR. ALLEY & MC LELLAN, LTD., GLASGOW

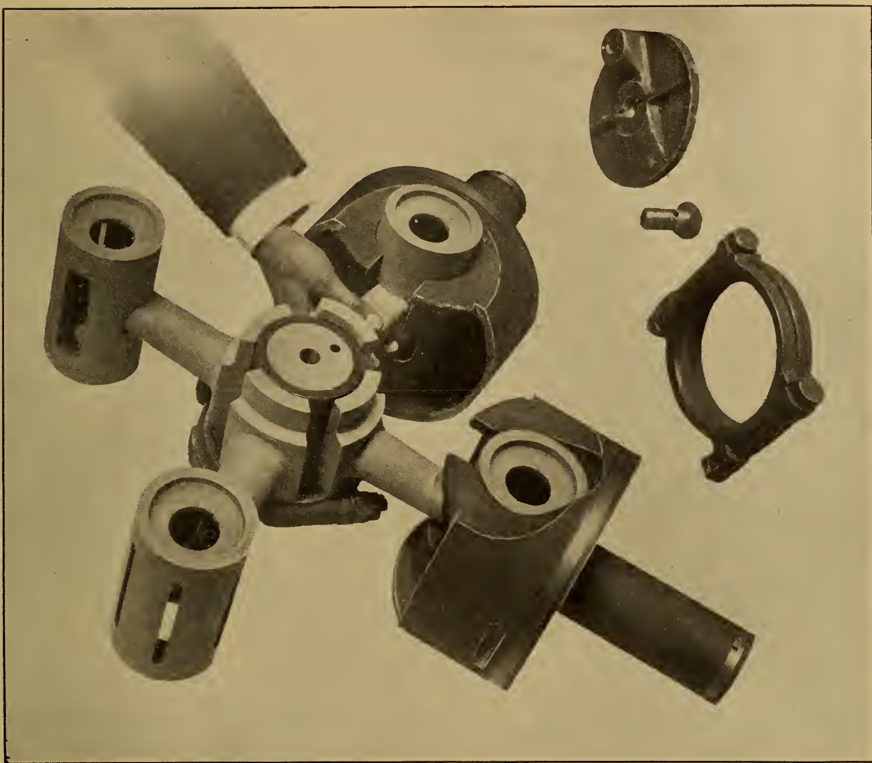

FIG. 30.—ARRANGEMENT OF WORKING PARTS OF REAVELL COMPRESSOR

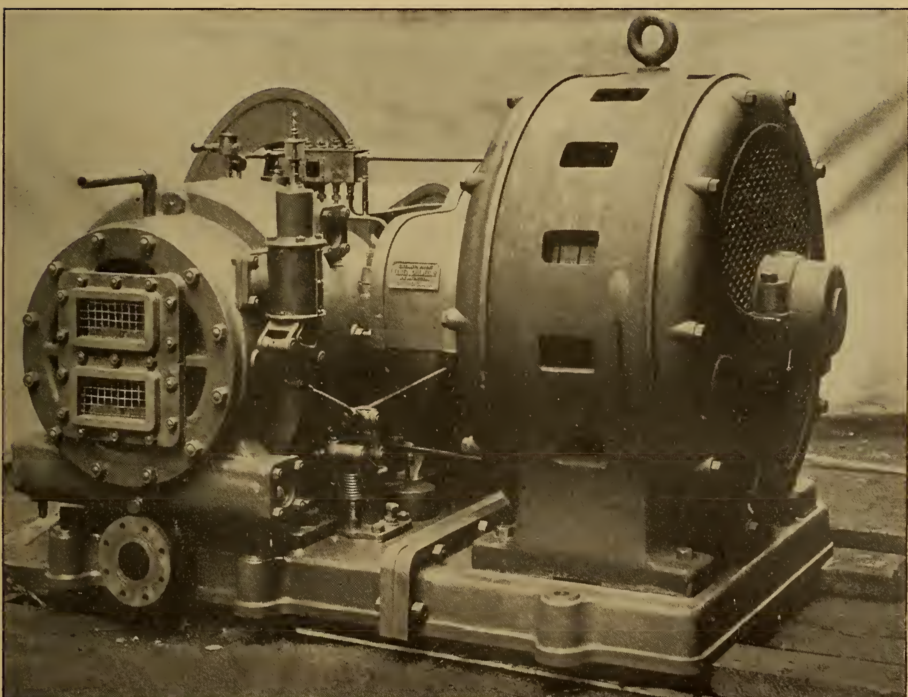

FIG. 31.—ELECTRICALLY-DRIVEN COMPRESSOR FITTED WITH GUTERMUTH VALVES. FRASER & CHALMERS, LTD., LONDON AND ERITH

speed compressor is that shown in Fig. 31. The principal interest in this machine is the application of a reciprocating piston combined with the Gutermuth valve gear. The governor-valve gear on this compressor is so arranged as to put the suction and delivery chambers into partial connection if there is an excess of air.

Lishman & Simpson's air compressor presents novel features. It is of recent invention and is of a semi-rotating type. Fig. 35 shows one of these machines capable of delivering 850 cubic feet of air per minute against 75 pounds pressure for coal-mining work. The cylinder is circular and divided into four quarters; in each quarter is a blade attached to a common shaft. These blades are fitted with wedge-shaped sides and ends pressed against the cylinder sides and faces by springs to take up such wear as may occur. The suction of air takes place through a port, which is closed by the fin or blade as it passes around the arc of the circle of the cylinder. The delivery valves are of the usual spring-loaded type. The alteration from rotation to semi-rotation is effected by a connecting rod, which is attached to a swinging arm on the end of the shaft holding the blades forming the piston of the compressor. The radiation of heat from the cylinder is very good and practically no evaporation takes place from the cooling tanks used to circulate the water through the cylinder jacket. Owing to the accuracy with which the position of the piston blades can be fixed, the volumetric efficiency of this machine is very high. The overall efficiency between input and indicator diagram on the cylinder when doing work is between 81 and 83 per cent.

No account of air compressors would be complete without reference to the machines made by the Westinghouse Company. These were primarily adopted for train brakes, but have been developed for other industrial uses. The compressor in general used by the Westinghouse

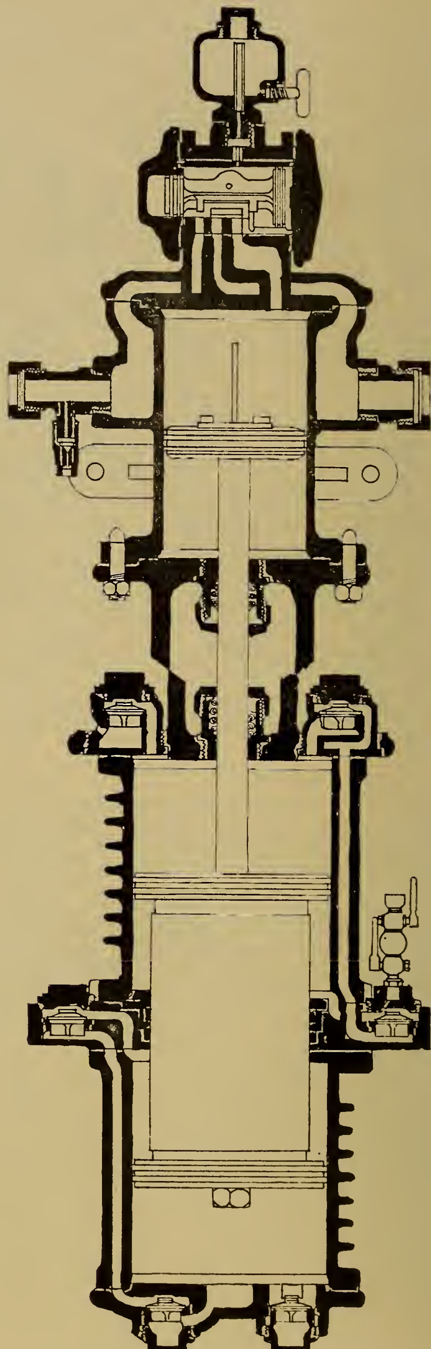

FIG. 32.—SECTIONAL VIEW OF WESTINGHOUSE DIRECT-ACTING TWO-STAGE AIR COMPRESSOR. WESTINGHOUSE BRAKE COMPANY, PITTSBURG, LONDON, ETC.

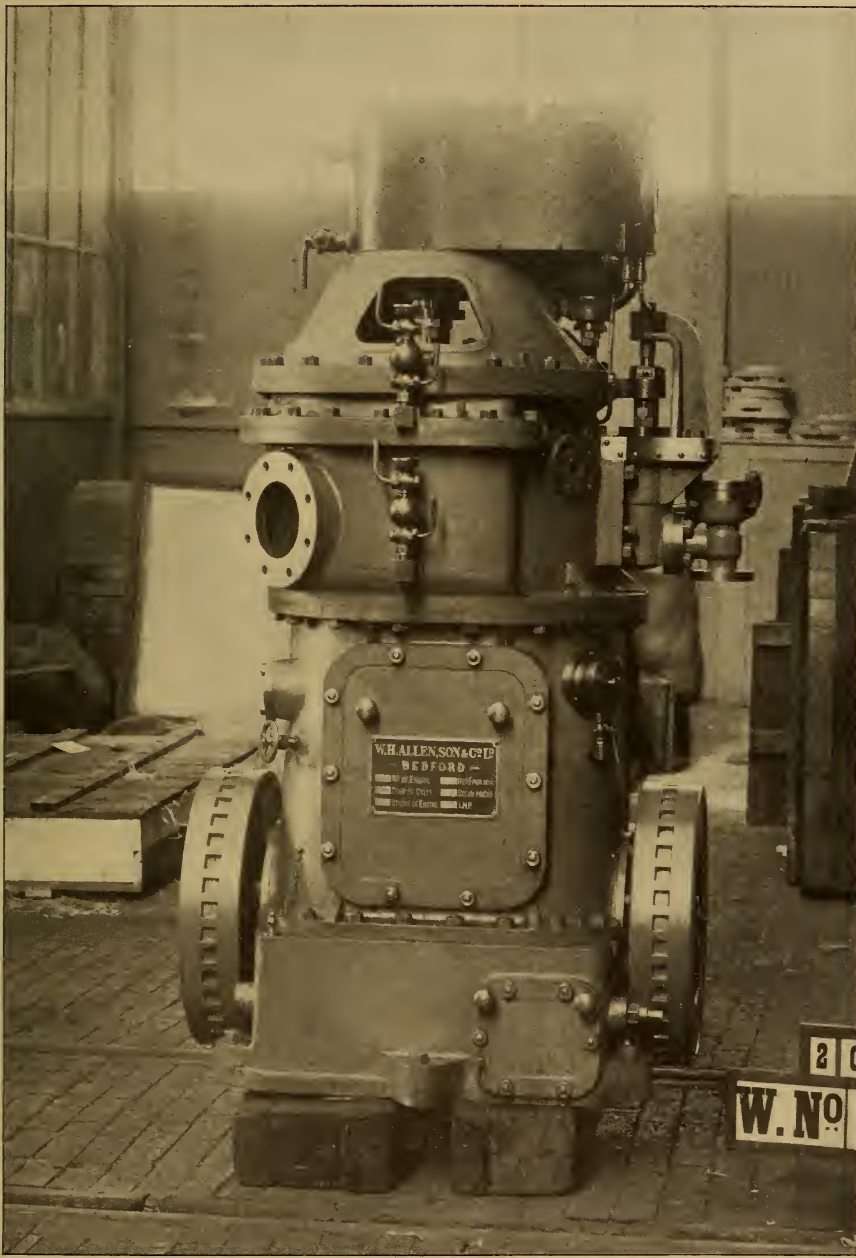


FIG. 33.—STEAM-DRIVEN, DOUBLE-ACTING COMPRESSOR. W. H. ALLEN, SONS & CO., LTD., BEDFORD

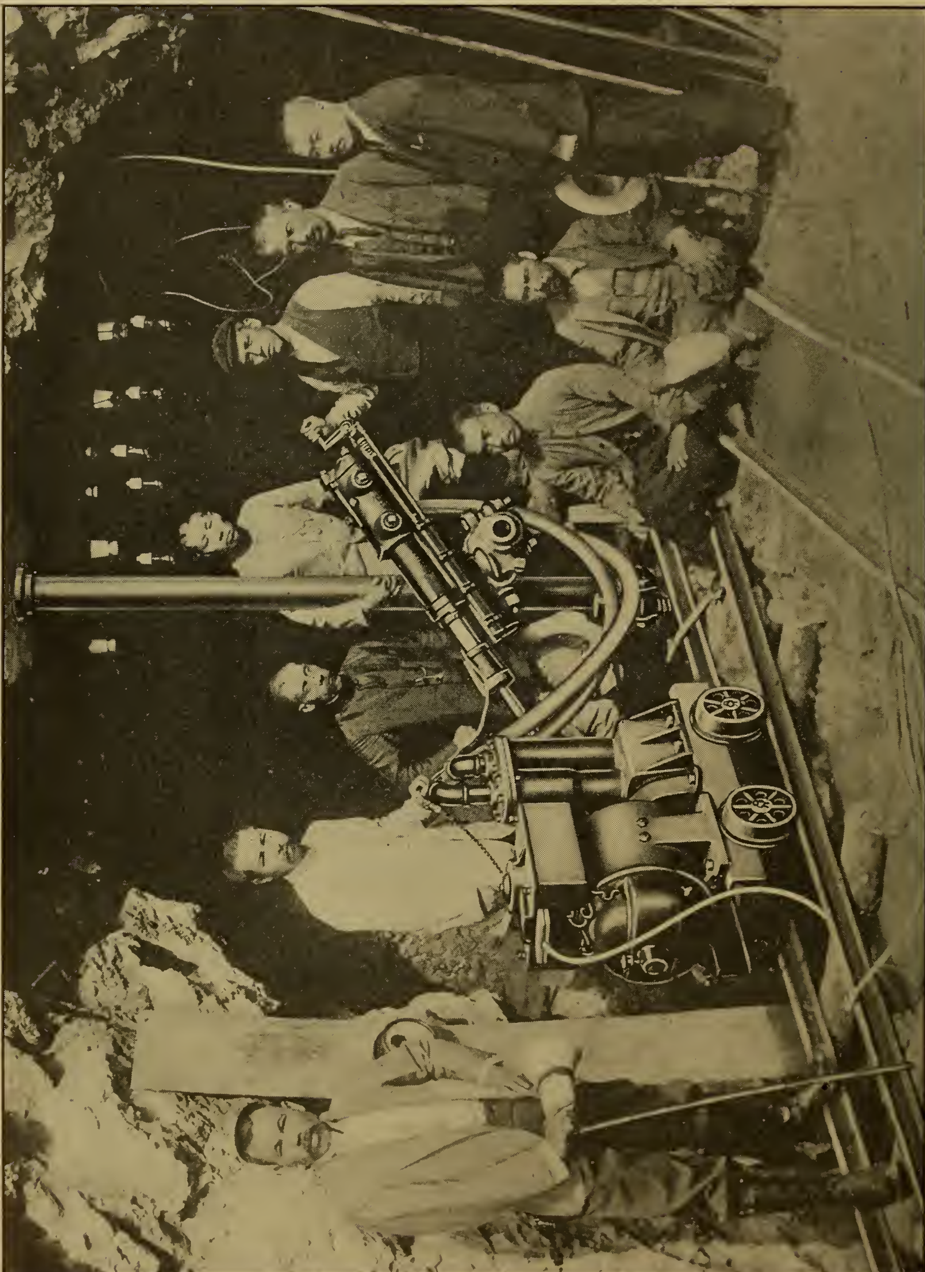

FIG. 34.—TEMPLE-INGERSOLL ELECTRIC-AIR DRILL AT HASAM GOLD MINE, KINSHIU, JAPAN

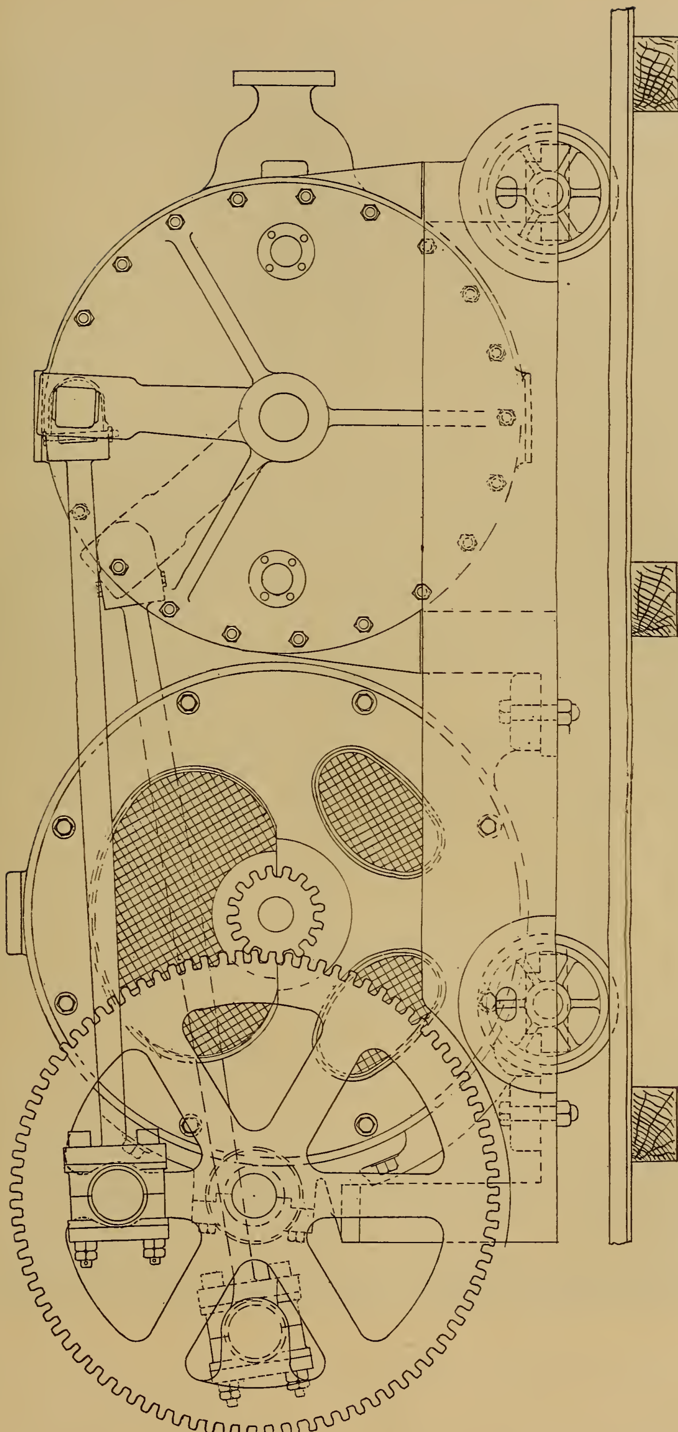

FIG. 35.—LISHMAN & SIMPSON SEMI-ROTATING COMPRESSOR. SIDE ELEVATION OF MACHINE COMBINED WITH ELECTRIC MOTOR

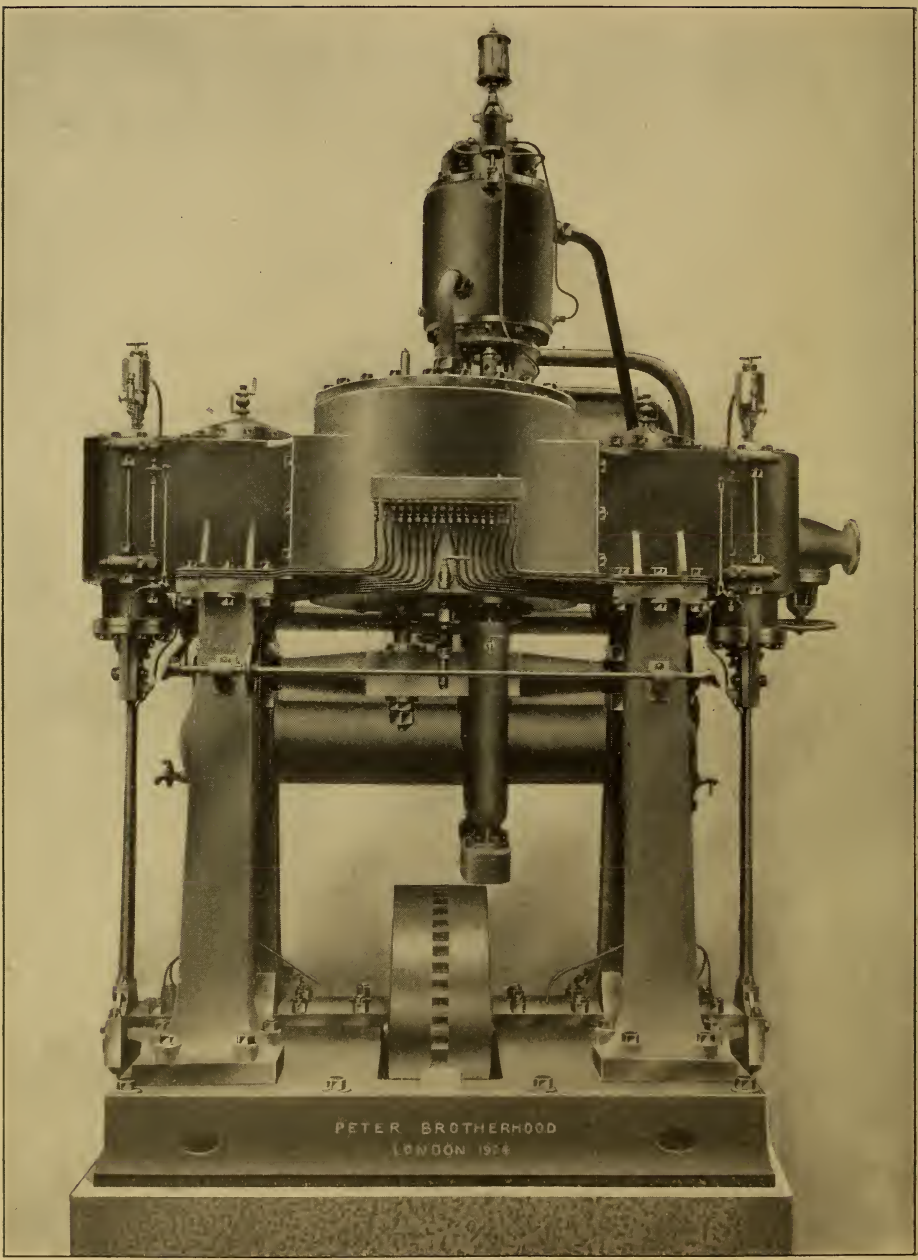


FIG. 36.—HIGH-PRESSURE AIR COMPRESSOR FOR PRESSURES UP TO 2,500 POUNDS. PETER BROTHERHOOD, LTD., LONDON AND PETERBOROUGH

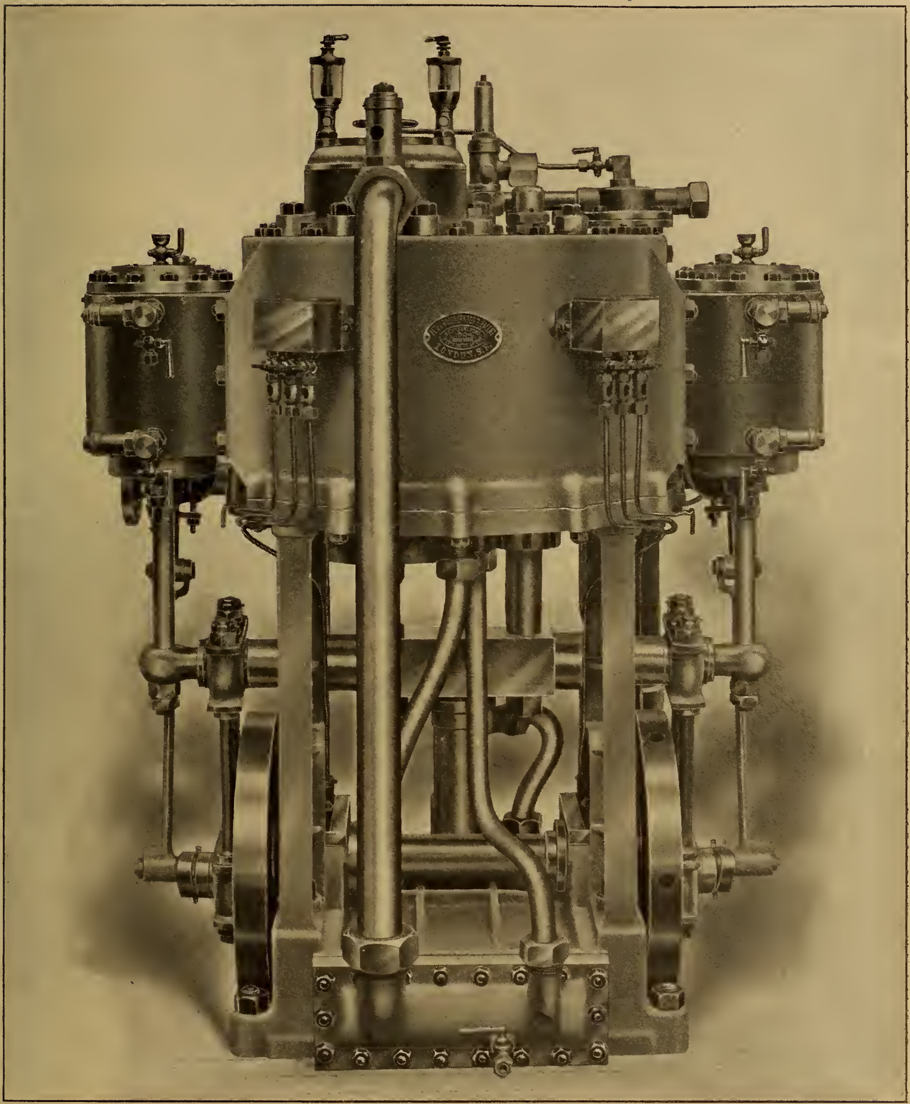

FIG. 37.—HIGH-PRESSURE AIR COMPRESSOR FOR PRESSURES UP TO 3,500 POUNDS.
PETER BROTHERHOOD, LTD., LONDON AND PETERBOROUGH

Company is made on much the same principle as a direct-acting duplex pump. The machine is made either for single or double stage. The illustration (Fig. 32) shows the pattern used as a two-stage machine. The pistons are joined together by a drum, which is properly packed, to prevent leakage from one cylinder to the other.

The Ingersoll-Rand Company have recently placed on the market a type of air compressor presenting novel features. The air in this case is compressed, exhausted, and re-compressed in the same cylinder, and not as in the ordinary case—compressed and exhausted to atmosphere. The machine is essentially one which requires electricity as the motive power.

It consists of a motor-driven single-acting duplex compressor without any valves. The speed can therefore be varied at will, according to the work to be done. The air is compressed in one cylinder and developed through a short length of hose to one end of a piston in the drill or pneumatic tool, and at the end of the stroke of both compressor and drill the other side of the compressor or drill does the same thing. The whole action of the two machines (the drill and the compressor) is one of giving an alternating impulse of air to each end of the tool to be operated. The percussive action of this combination can be made very effective, and it is practically impossible for a drill to stick in any position, such as often happens with steam or other percussive drills. To obtain reasonably good efficiency it is necessary to place the compressor and the machine to be operated within 4 to 6 feet of each other.

The use of compressed air to very high pressures for torpedoes, gas compression in chemical works, etc., involves the manufacture of compressors of a specially strong construction. The general principles being the same, it is only a question of strength of material and disposition of working parts to ensure a reliable machine. Figs. 36 and 37 are illustrations of these special machines.

There are, of course, many other types and makers of air compressors than those which have been described above, and in a future contribution it is proposed to deal with the special machines which could not be included in the necessary limitations of this article.

# EFFECTIVE BEACH PROTECTION

By Lewis M. Haupt, M. Am. Soc. C. E.

A THOUSAND years ago the Chinese built a great wall around their empire to defend it from predatory barbarians and spoliation, but to-day they are learning that the "open door" for commerce is a far more valuable asset for the welfare of their people.

Freedom of exchange, circulation and trade are fundamental factors in the progress of nations, and to secure these benefits open ports are fundamental, especially in view of the enormous development of the ocean carriers, but Dame Nature has placed a limit of draught at the various inlets along the coast, where she has erected a submerged barrier, seldom more than fifteen feet below the surface, to barricade the ports, and for all time she is incessantly bombarding the enceinte along shore and driving the comminuted particles of rock into the harbor entrances, flanking them one by one, and finally closing them entirely from access by the sea.

The narrow strand where the breakers roar as they rise to the charge is the line of battle, so fascinating to the multitudes who crowd the shore for recreation or for gain during the summer, but how few fully appreciate the magnitude of the forces which are so wantonly wasting their riparian property and carrying it to others having no inherent right to these gratuitous possessions.

Many futile attempts have been made in all countries to control these forces by protecting works, and the consensus of opinions as to their proper utilization is very conflicting.

After many centuries of experiment, the engineers of Europe, especially those of Holland, Great Britain, and France, have concluded in substance that as to the relative efficiency of high or low spur jetties, the low ones gave better results in general, and that jetties were cheaper and far preferable to continuous sea walls.

When sea walls were necessary, then one built out in steps, rather than on a gradual slope, is preferable, but a concave, curved wall to reflect the wave seaward and prevent it breaking over the parapet, is the best form. A high wall placed on the high-water line is to be condemned as forming one of the most effective excavators of a foreshore that could be imagined. As to the impounding of the littoral drift along shore it is impossible to lay down any hard-and-fast rule, as the conditions are so variable. In some places it travels in the direction of the prevailing winds, in others in nearly the opposite direction. The amount of money which has been frittered away in useless devices for checking the drift is appalling. The opinion that spur jetties are an essential element in any effective scheme for defense is altogether a mistake, and they are unsightly as well as inconvenient obstructions to beach traffic, while as a means of coast protection they are, speaking generally, a complete failure, and the money spent upon them is wasted. Any object in the sea intended to coerce is a source of danger, foredoomed sooner or later to complete failure. Persuasive methods must be adopted to drive the high-water line seaward, which cannot be done by the construction of groynes or high jetties, whereas excellent results have been secured on the New Jersey coast (in the United States) by the use of short-curved

FIG. 1.—PILE JETTY AT ATLANTIC CITY; WRONGLY PLACED

jetties properly oriented with reference to the prevailing forces and their resultant drift. A sea-wall is not a true remedy, but only a palliative in substituting a harder for a softer material; relief must come from a thorough study of the nature of the forces at the site and their proper utilization.

The above greatly condensed opinions indicate the chaotic condition of the science of beach protection, and it is evident that a purely local treatment may do more harm than good, and that the general conditions should be carefully considered before any remedy can be successfully applied. The relation of cause and effect should be observed, and the particular stage of the cyclic changes be ascertained before any improvements are begun. It is misleading to note the sequence of positions as determined by dates alone, as indicating the direction of the drift, but attention must be given to the topographic forms which are the most certain indices. Other factors of great service are the general contours of the coast, the amplitude of the tides, and particularly the prevailing angle of wave approach at flood tide, so that the correct solution of any problem involves a broad investigation of ocean dynamics for the best results.

Failing this research and following blindly certain precedents which appear to have been successful in one position, the inexperienced builder has found that his experiment has not proved to be applicable under the new conditions existing at a different site.

For a few practical illustrations attention is called to some of the changes which have recently taken

place along the New Jersey and Long Island coasts, which have become valuable as pleasure and health resorts in recent years.

In a paper on the "Menace to the New York Entrance" the writer has called attention to the great erosion caused at Barren Island and Manhattan beaches by the rapid advance of the bar in front of the Jamaica Bay inlet, which has moved westward some three miles in sixty years, and which already threatens the Ambrose channel, now being dredged for the largest steamers entering that port. Soon Coney Island will be masked by a long spit similar to Sandy Hook, which is its counterpart, from the New Jersey drift advancing on the opposite flank and tending to shoal the entrance and inner bays. The more than thirty inlets along the seaboard between New York and Delaware Bays, which were open a century ago, have been closed in large part, so that only about nine remain, and most of these are not accessible for vessels of over six-feet draught.

At the southern end of Brigantine beach some 238 acres were cut away in less than a score of years. At the end of Absecon the shore line receded over a half mile, carrying away some 76 acres, while 82 acres were deposited farther southwest, and at Great Egg Inlet over half a square mile has been carried across the inlet and contributed to the easterly end of Peck's beach. The general direction of the drift along this littoral is southwest from Bay Head, where the nodal point is found, to Delaware Bay, and northeast to Sandy Hook, so that it cannot be due to the prevailing winds alone, as has been claimed.

FIG. 2.—STONE AND PILE JETTY AT ATLANTIC CITY

Between Seabright and Manasquan, where the coast is already well populated, many efforts have been made to protect the beach from erosion by various devices placed across the strand, some of which are worse than useless. The usual spur jetty built out normally from the boardwalks has for a time embayed the sand in the coves thus created, but it is characterized by the fill on the southerly side and the cut on the leeward, indicating the travel of the drift over the intended barriers.

Numerous jetties of various forms and construction have been built at Atlantic City to recover lost territory, but to little effect. Thus in Fig. 1 is seen the remains of a single row of piling curving to the southward, in imitation of a curved jetty formally built at another point of the beach, and which is so remarkably successful in accumulating sand that the proprietor wrote soon after it had been placed and had excited the ridicule of the proverbial "oldest inhabitant," as follows: "The jetty has within the last four months made an accretion of about 110 feet of land for us, and has attained a height of fully nine feet. I have never known anything to act so quickly, and it is the talk of the old-time people of Atlantic City at the marvelous results obtained by the jetty. You certainly should be congratulated upon the good results that have been obtained

FIG. 3.—PREPARING CAISSONS FOR JETTY

FIG. 4.—SAND FENCES

upon your recommendation and direction in placing this jetty where it is, as it is reclaiming more land than I had deemed possible." Yet the somewhat similar jetty shown in Fig. 1 has fallen to decay and does not give any evidence of having accumulated any drift on either flank. A still more expensive structure built of two rows of piles filled in with stone, and constituting a low spur jetty, said to be so effective, gives no evidence of beneficial results, although it is said to have cost over $30 per lineal foot (Fig. 2). Still a third form, consisting of wooden boxes or caissons floated out to position, anchored to piles and sunk by filling them with sand bags. is being used near the life-saving launching station at Pacific avenue (Fig. 3); but a much cheaper form of sand fence has been extensively used at the southerly end of the island, where it is reasonably effective (cost being considered) in holding the beaches in place, as shown in Fig. 4. At the head of the island, exposed to the easterly storms and currents, the shore is subject to erosion, with comparatively little drift passing out with the ebb tide, and to protect this frontage some simple spur jetties were built in 1899, as seen in the demoralized piles of Fig. 5, which shows the low-water line outside of the boardwalk, looking northward towards the inlet. Fig. 6 illustrates the same

frontage inside of the walk at high water, with the bulkhead of two rows of piles filled in with stone ballast, built at the same time. These works have served a useful purpose in retaining the ground and preventing erosion, but the property having recently changed hands the new proprietors concluded to authorize a small reclamation jetty to be placed at one end of the tract for the purpose of recovering some of the lost frontage.

The work was constructed during the months of June and July, and was completed to a length of 130 feet from the boardwalk on the 25th of the latter month. When it was staked out the survey showed the low-water line to be but 27 feet from the edge of the walk, while the bathing master at the site reported on Aug. 17, a few weeks after completion, that it was possible to walk around the outer end of the jetty at low water dry shod. The form of this sand trap is seen in Fig. 7, taken on July 29, showing the filling in of the groyne on the southerly side, while the photograph, Fig. 8, illustrates the action of the waves and surf and the filling of the north side by the drift. The outer end is in about 2 feet of water, where a few days before it was nearly 5 feet deep, and where it is now bare at low water.

Thus this jetty appears to have fulfilled the requirements of the forces

FIG. 5.—ATLANTIC CITY. REMAINS OF OLD JETTIES

FIG. 6.—ATLANTIC CITY. INSIDE OF BOARD WALK AT HIGH TIDE

at this site and does not do violence to them by scouring a hole at the outer end, nor does it develop cross-currents, but trains the drift ashore as designed.

To further assist in building out this beach a short sand fence 100 feet in length was erected about the middle of the block at a cost of less than one dollar per lineal foot, as shown in Fig. 9.

The ordinary type of the said jetties as constructed on the north Jersey coast is of timber, projecting straight out to sea and bolted strongly to heavy piling. These answer the purpose well, but are not sufficiently high to prevent the travel of the drift over their crests, nor do they act to drive it shoreward.

A few years since the Board of Chosen Freeholders of Monmouth County authorized a jetty to be built on the south bank of Shark River, which was intended to protect its mouth from the drift, and the work was planned for this purpose with a grade sufficiently high to prevent its being overtopped, and of such length as to impound the shore drift, but on inspecting a portion of the work the committee feared it would be undermined and topple over, and so ordered the contractor to omit about four feet of the upper section, as shown in Fig. 10, thus defeating the main purpose of the work, and it was also ordered that the outer 200 feet be omitted, as the water was considered too deep for safe construction. As the sand very soon filled to the top of the lower section, where

FIG. 7.—SOUTHERLY SIDE OF RECLAMATION JETTY, ATLANTIC CITY

the children are standing, consent was secured to place a light superstructure on top, as shown in Fig. 11, with the result that in a few weeks it had impounded the drift and filled up almost to the top, as is seen

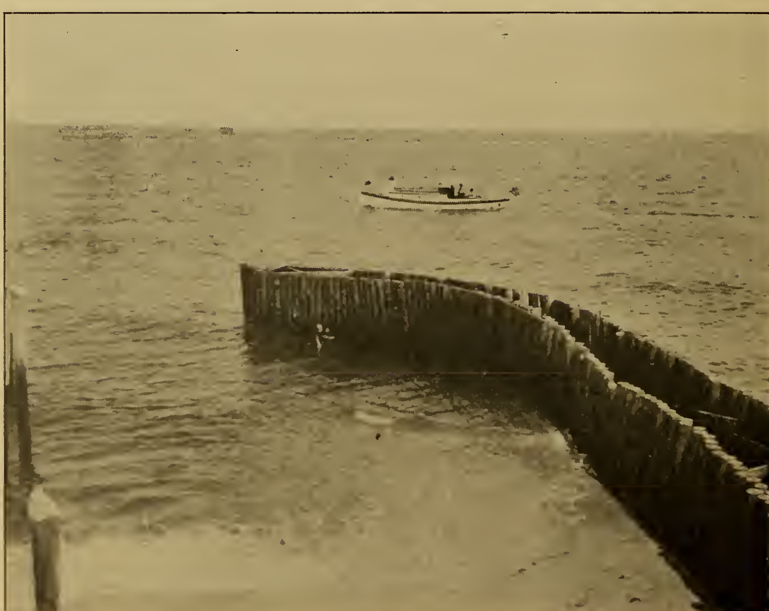

FIG. 8.—NORTHERLY SIDE OF RECLAMATION JETTY, ATLANTIC CITY

FIG. 9.—SAND FENCE AT ATLANTIC CITY

in Fig. 12, which gives a clearer idea of the form of the curve in this case. It was unfortunate, however, that the jetty was not extended to its original length, since the sand has advanced to and beyond its end and the drift has resumed its sway, thus again closing the inlet.

FIG. 10.—RECLAMATION JETTY, BELMAR, N. J.

FIG. 11.—BELMAR JETTY AS BOARDED UP TO GRADE

The sequel to this is the fourfold effort to reopen the river by cutting a ditch across the sand spit, which was finally successful.

FIG. 12.—RECLAMATION JETTY AT BELMAR, FILLED IN ON SOUTH SIDE

# LONG-DISTANCE ELECTRICAL TRANSMISSION

By C. J. Spencer

THE object of this article is to consider the desirability for a new type of generator suitable for long-distance transmission of electric energy, to demonstrate the limitations of present systems for long-distance transmission, and to describe several methods suggested for overcoming these limitations.

Power can be produced economically at centers like Niagara Falls by utilizing the immense water power there available, and sufficient power is there produced for the supply of demands in a territory of approximately 100 miles distant therefrom. While objections have been raised to the diversion of water from the falls for industrial purposes, the immense value of the power would no doubt overcome all objections were it not for the fact that present systems of electric distribution are limited as to their economical range of application.

Another immense water power, in South Africa, the Falls of the Zambesi, has been recently made accessible to the tourist, but as yet it has not been developed, mainly on account of the inadequacy of present systems to transmit electric power over distances of, say, 400 miles, to commercial advantage.

At the present time, coal is transported from the mines to large cities at less cost than electric power can be transmitted from the mines to these cities, when the cost of the lines, with equal security from interruption of service, is considered.

The above conditions lead to a consideration of present methods of long-distance electric power transmission.

At the present time power is transmitted over distances of 100 to 200 miles by the utilization of alternating current at a voltage of 60,000 volts and at a frequency of 25 cycles per second. Generating stations have been built with provision made for raising the voltage to 88,000 volts at some future time, and plans have been drawn for stations to be operated at 100,000 volts, so that at the present time 100,000 volts may be taken as the limit for commercial operation.

An inquiry at once arises as to the reason for settling on 100,000 volts as the limit to the voltage. With high voltages, that is, from 30,000 to 100,000 volts, bare wires in air discharge current from one wire to another wire of opposite polarity. This effect is known as the corona effect. It is apparent when wires of any definite size are placed at less than a distance apart which can be calculated with accuracy for any given voltage. Where the voltage is determined, this effect can be prevented by using larger wires or by placing the wires at greater separation distances. However, the cost of the wires increases with their size and the cost of the supports for the wires increases with an increase in separation distances, so that the total cost of the intallation must be considered. With the present method of line construction, utilizing bare wires placed on poles, the corona effect prevents the application of voltages higher than 100,000 volts, especially since this effect becomes apparent with much greater separation distances and increase in size of wires in proportion to the increase in voltage above 100,000 volts.

In fact, bare wires in air require such a large air space and such large wires at a voltage of, say, 150,000 volts, that the cost of the line is considered prohibitive. The amount of moisture

contained in the atmosphere certainly affects the limitations of high voltage transmission, but even with what is known as perfectly dry air the cost of a line for operation at 150,000 volts is now considered so high as to prohibit the standard method of construction. Therefore, since bare wires cannot be installed for such voltages at a reasonable cost, some other insulation than air, which by reason of its greater strength than air to resist the dielectric stress results in a more economical total cost, must be adopted.

Oil is such an insulation and probably would be adopted for this purpose were it not for the difficulty of supporting the wires central with the containing vessel. Some insulating substance may be found that could be laid in troughs on the ground surface and of a consistency that would permit of supporting the weight of the wire. Should insulated wires be used, they would probably be laid on the ground or buried underneath the surface to minimize interruptions from disturbances due to the weather.

Underground wires as now installed are insulated with paper or rubber compound protected by a lead sheath and the complete cable drawn into tile ducts. The cost increases so rapidly with increase of voltage that the limit for commercial operation with underground cables is now considered to be 20,000 volts. Above this voltage such large amounts of material are required that some other system must be adopted. But there is no good reason for adhering to past and present methods of construction provided some better method can be found, and that method depends on the dielectric strength of the substance utilized as compared to its cost.

Besides the corona effect incurred by increasing the voltage of the line above a determined maximum, a certain amount of current is taken by the line for charging it to the impressed voltage. An alternating voltage increases to a maximum positive value, diminishes to zero, reverses to a minimum negative value and again returns to zero. At a frequency of 25 cycles, these changes in value occur twenty-five times per second, charging the line alternately, positively and negatively at the rate of fifty times per second. This current becomes appreciable in amount with long lines operated at high voltages, and increases with increased length of line and rise of voltage to such an extent that the full capacity of the generating plant cannot be transmitted to very long distances. The charging current can be reduced by decreasing the size of wires and by placing the wires at greater distances apart, when the frequency is determined. It is impossible to reduce the size of wires below a fixed minimum size, as the corona effect would then occur. The wires may be placed at greater distances apart until the distance between wires is equal to twice the height of the wires above ground. Beyond this amount no further gain is obtained, for a neutralizing current then flows through the ground. Therefore, the wires cannot be erected on separate poles or towers for the purpose of minimizing the charging current. The charging current can, however, be reduced by decreasing the frequency of alternations.

The loss in potential when electric power is transmitted consists of two factors; namely, a resistance loss and an induction loss. The resistance loss is fixed by the size of wires and the current carried by them; it can be made as small as desired by means of large wires. The inductance loss cannot be diminished directly as the increase in size of wires on account of its dependence on the space enclosed with the circuit. Where this space is fixed, as it must be by the limitations of corona effect and charging current, some method other than the alteration of size of wires must be adopted. The inductive loss depends on the frequency, being less for low frequencies than for high frequencies. The frequency is then the only variable of the electric circuit which can be changed to advantage.

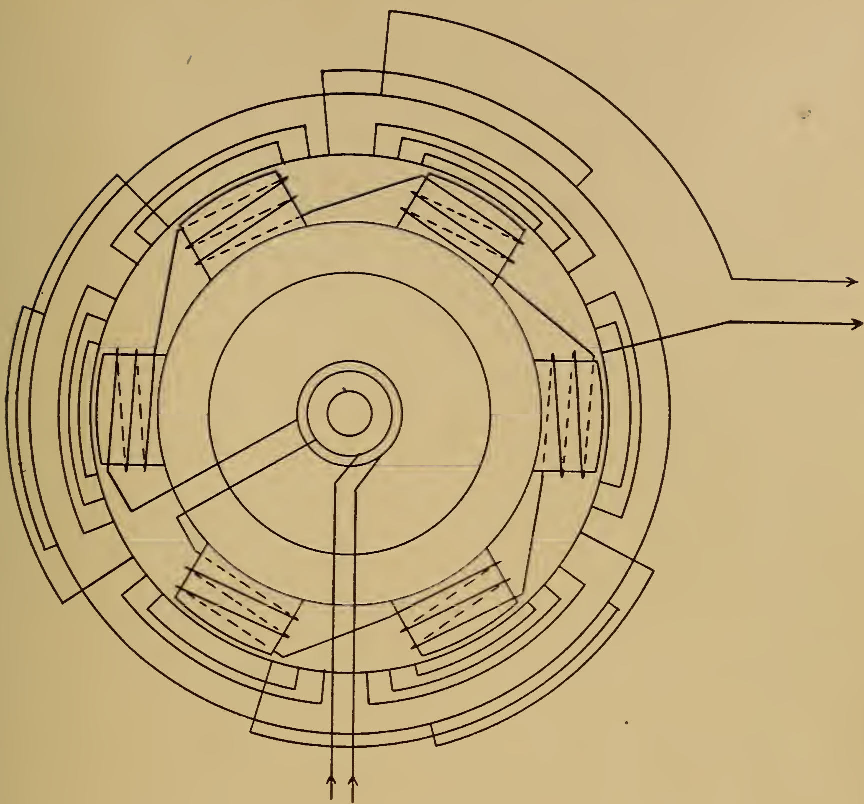

FIG. 1.—WIRING DIAGRAM OF ALTERNATOR

When the alternating current was first introduced, a frequency of 133 cycles per second was chosen as best suited for the system. As the size of plants was increased a lower frequency was found to give better results, frequencies of 125, 60 and 25 cycles having been adopted successively. Now, a frequency is proposed for very large power and long-distance transmission at 15 cycles per second. In the future, frequencies of 10, 5 or one cycle per second or any number per minute may be chosen as the amounts of power and distances of transmission increase; but we know that the limit to the reduction of frequency is the direct current, so that, if we could make a generator for supplying direct high-voltage power, we should obtain the maximum efficiency, so far as frequency is concerned.

By the adoption of direct current instead of alternating current for transmission the inductive loss in potential and the loss due to the charging current would be eliminated. With direct current the line is charged once on making the circuit and no further loss is entailed. The elimination of these two losses would be sufficient to increase the scope of electric power transmission very materially when considered from a commercial viewpoint, provided we could make a generator suitable for producing high-voltage direct electric current and having an efficiency comparable with the present alternating generators.

Taking our cue from present practice, we find that alternators are built for a comparatively low voltage, the voltage being raised by means of static transformers. The reason for this

lies in the fact that manufacturers find they can build a combined unit, consisting of transformer and generator, cheaper than they can build the generator alone to produce current at voltages above 11,000 volts. A transformer consists of two windings about an iron core. A generator has many coils of wire distributed about its circumference. Not only is the amount of insulation about the many coils much greater than that about the transformer windings, but also the space necessary for the insulated coils of a high-voltage generator requires extremely large generator parts. Therefore, the means for producing a high-direct voltage would be most economically attained through the medium of some simple device auxiliary to the generator.

Of the commutator types of machines, M. Thury has developed that which gives the highest voltage. He obtains 10,000 to 20,000 volts with machines in series. However, this is not sufficient to warrant the choice of direct in preference to alternating current. The brush friction would affect their efficiency and the multiplicity of parts would affect their cost, should a very large number of these machines be connected in series.

The excitation of a standard alternator with alternating current instead of direct current is the most common of the many methods proposed for obtaining direct current without commutation. Such a machine is shown diagrammatically in Fig. 1. Direct current is supplied to the revolving field ordinarily and alternating current is obtained from the stationary winding. Direct current would be obtained apparently if alternating current should be used for excitation. This is not true, as demonstrated in the following paragraphs.

Consider alternating current to be supplied to the field pole, shown in Fig. 2, as it approaches the coil. Also consider this current to be of a frequency the same as that of the alternator when excited by direct current. A six-pole machine is shown. If it be operated at 500 revolutions per minute and excited by direct current it would produce alternating current at 25 cycles. Suppose alternating current at 25 cycles be used for excitation, that this current be increasing in value as the pole approaches the coil, and that this current reaches its maximum value when the field pole is exactly centered with the coil. If the field pole were stationary and 25-cycle alternating current were used for excitation, the magnetic flux through the coil

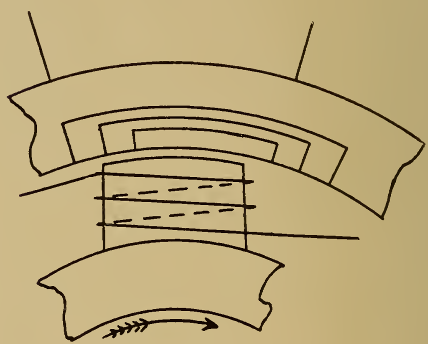

FIG. 2.—SECTION OF ALTERNATOR

would vary at the rate of 25 cycles per second. With the field revolving at 500 revolutions per minute and the alternating current of 25 cycles used for excitation, the effect would be the same as would be obtained by running the field at double normal speed. When the field is run at double normal speed a frequency of twice normal is obtained. Consequently, we should expect an alternator running under these conditions, with alternating field, as stated above, would produce alternating current at 50 cycles per second instead of the direct current desired.

Another supposition in the relative positions of field pole and generating coil may be so chosen that the exciting current is diminishing as the pole approaches the coil, and is at zero value when pole and coil are centered. In such a case there would be no change of magnetism in the generating coil and no voltage or current would be generated.

A third selection of these positions

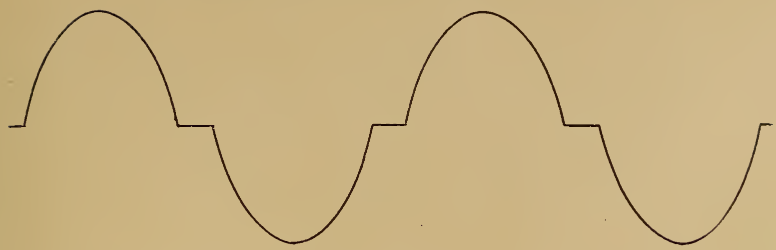

FIG. 3.—WAVE OF ELECTROMOTIVE FORCE PRODUCED BY ALTERNATOR WITH ALTERNATING EXCITATION AND FIELD POLES DISPLACED FROM CENTRE GENERATING OF COILS AT TIME OF MAXIMUM FLUX DENSITY

gives some promise of results, in that a voltage is generated which presents facilities for commutation. Let the pole be a certain small distance off center from the coil when the exciting current is maximum. Then the voltage generated would be as shown in Fig. 3. To obtain this result with exactness and precision the exciting generator must be rigidly connected to the main alternator shaft. The voltage, as shown, remains at zero value for an interval of time. If the current followed the voltage as it does with unity power factor, the power could be rectified without serious sparking even with moderately high voltages.

A charging current is supplied to transmission lines which varies when the voltage changes in value. In order to prevent confusion with the charging current on alternating systems, let us consider this charging current as due to a quantity of electricity flowing in and out of the line. The quantity of electricity is in phase, very nearly, with the voltage. Actually the flow of this current lags slightly, due to the inductance of the line and the hysteresis lag of any dielectric. Disregarding this slight lag, the quantity of electricity is seen to change in value at a very low rate where the voltage is maximum and at a greater rate where the voltage approaches zero. The rate of change in electricity is greatest when the voltage reaches zero. The rate of change of electricity is the current. Therefore, the charging current is at its maximum when commutation takes place and would cause sparking if an attempt be made to rectify it.

FIG. 4. WAVE OF ELECTROMOTIVE FORCE WITH SPECIAL EXCITER

The change in voltage from a finite value to zero should be gradual, as shown in Fig. 4. If the change in voltage as it approaches zero be so gradual that the curve representing it be asymtotic to the line of zero value, then the rate of change of electricity would be zero at this point, and the charging current would be zero, as shown in Fig. 5. Here it can be seen that the charging current is zero as the voltage builds up from zero, reaches a maximum as the rate of change of voltage attains a maximum, and again falls to zero at maximum

FIG. 5.—CURRENT WAVE CORRESPONDING TO WAVE OF ELECTROMOTIVE FORCE SHOWN IN FIG. 4

voltage where the rate of change of voltage is zero.

This form of a voltage wave can be obtained by rounding the field poles of the exciting generator, as shown in Fig. 6.

This style of unit would probably give excellent results for commutation at high voltages even when long transmission lines are connected thereto. However, the space between commutator bars necessary for 100,000 volts would result in a commutator of large dimensions, and since the commutator must be run at high speeds to rectify an alternating power at 25 cycles, heavy centrifugal forces would be set up, probably sufficient to burst the commutator. The machine is, therefore, of little value for long-distance transmission. Also the fact that a commutator for rectifying high voltages cannot be built, is an additional reason for the attempt to obtain direct current from auxiliary devices.

Two sources of alternating electromotive force and current, displaced by an angle of 180 degrees and so connected that the maximum positive value of one equals the minimum negative value of the other, would give a pulsating current of unidirectional value between each wire and the neutral. Two such waves are shown in Fig. 7. These waves may be taken to represent voltage or current. In either case the voltage or current would be the equivalent of one wave along each outside wire of the system, that is, alternating, and the voltage for current along the neutral wire would be the summation of the two waves or zero. Both voltage and current would apparently be unidirectional through any apparatus connected between the neutral and one outside wire.

A connection of transformers, as shown in Fig. 8, apparently gives the desired result. The transformer primaries are connected in series to a single-phase source of supply. The secondaries are connected in series with a common neutral. The voltage and current as taken from the transformer secondaries are reversed with regard to each other; that is, they are

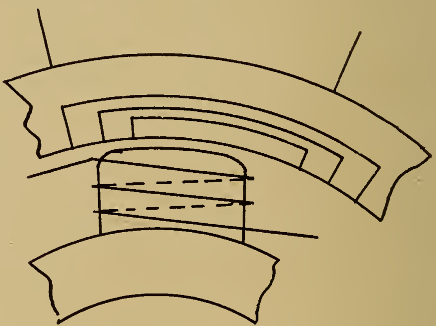

FIG. 6.—SPECIAL POLE PIECE

180 degrees apart. One desideratum is not fulfilled. The negative minimum value of one wave is not equal to the positive maximum value of the other wave. This requirement cannot be fulfilled except by interposing a source of direct power between the windings.

The actual wave along the neutral is as shown in Fig. 9. Transformers connected, as shown, are installed in many locations for the purpose of supplying 110-volt apparatus from 110-220 volt three-wire secondaries. No direct current or unidirectional current has been obtained.

A method of obtaining unidirectional power, at one time proposed by

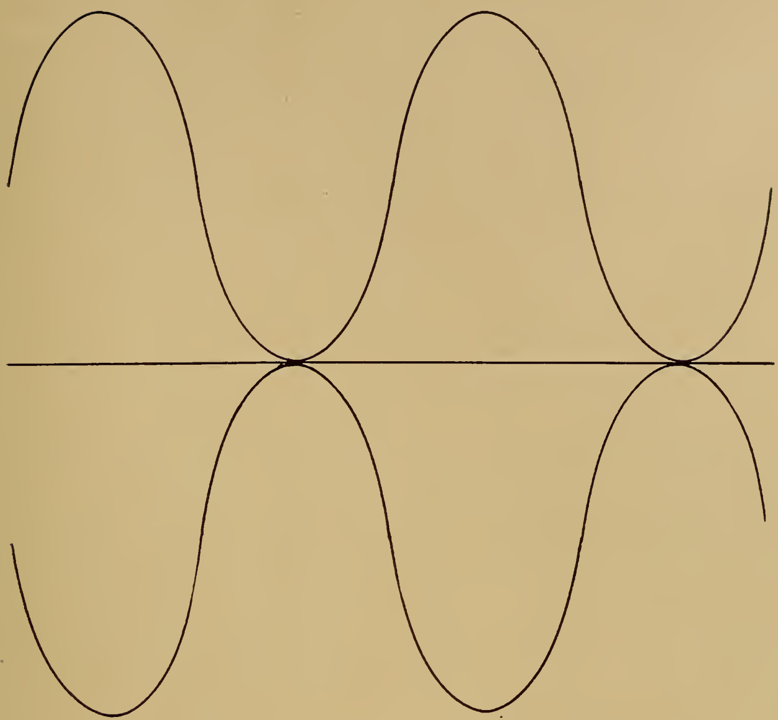

FIG. 7.—TWO WAVES OF ELECTROMOTIVE FORCE DISPLACED 180 DEGREES

several writers, is the combination of direct and alternating sources of supply, the direct supply having one-half the maximum range of voltage of the alternating. This combination is represented graphically in Fig. 10. The wave as shown is the equivalent of one-half the combination of alternating waves mentioned above. Objections which apply to this method also apply to the use of a source of direct power as found necessary for the combination of alternating waves previously discussed.

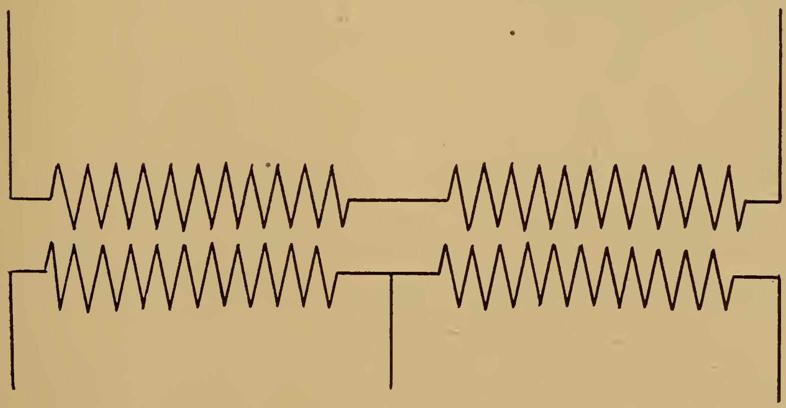

FIG. 8.—TRANSFORMER CONNECTION FOR PRODUCING ALTERNATING WAVES OF ELECTROMOTIVE FORCE DISPLACED 180 DEGREES.

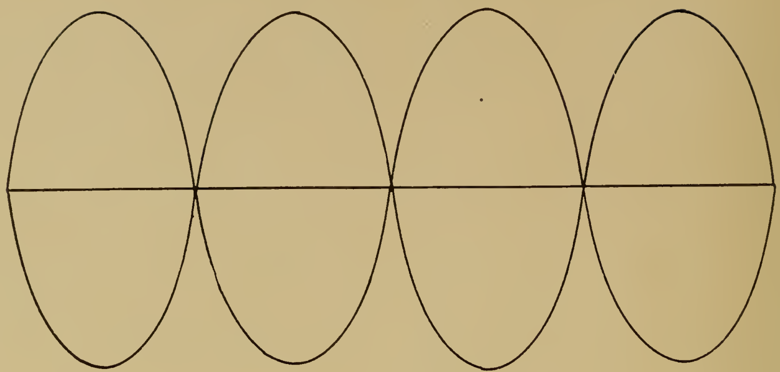

FIG. 9.—SUMMATION OF WAVES ALONG NEUTRAL WIRE OF A THREE-WIRE BALANCED SYSTEM

The voltage of an alternator is usually expressed in terms of its positive and negative values, both considered as positive, and these values in terms of the square root of the mean square of instantaneous values, or the effective voltage of the machine. Disregarding this customary nomenclature, the voltage of the alternator is just as definitely fixed by stating the voltage in terms of its maximum positive and negative values; in addition, we can neglect irregularities of wave form present in most types of alternators. The irregularities of wave form cause the maximum value of the voltage to depart from the value obtained by formulas based on the true sine wave relation of effective to maximum.

Let us consider an alternator with a wave of electromotive force varying from 500 volts positive to 500 volts negative, that is, a range of 1,000 volts, as connected in series with a 500-volt direct-current dynamo as shown in Fig. 11. Suppose the negative terminal of the dynamo connected to one wire of the feeder and its positive terminal connected to the alternator, the remaining wire of the feeder being connected to the opposite terminal of the alternator.

When there is no load on the feeder, that is, no outside connection between the wires of the feeder, the voltage only need be considered. At the moment the alternator produces 500 volts positive, its maximum positive electromotive force, the dynamo is also producing 500 volts positive and the voltage on the feeder is 1,000 volts. At the moment the alternator produces 500 volts negative the dynamo is producing 500 volts positive and the volt-

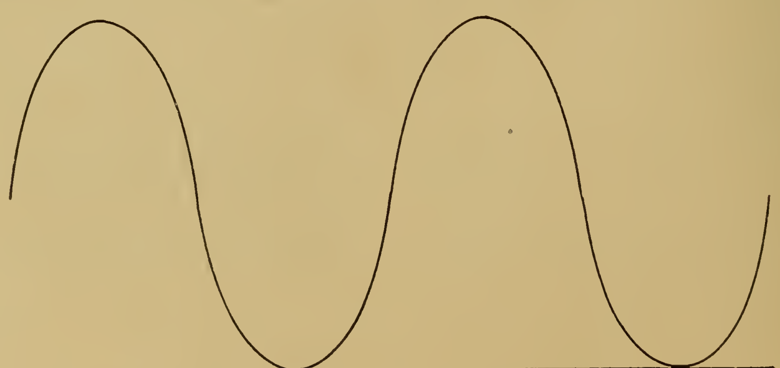

FIG. 10.—ALTERNATING ELECTROMOTIVE FORCE IMPRESSED ON A DIRECT ELECTROMOTIVE FORCE

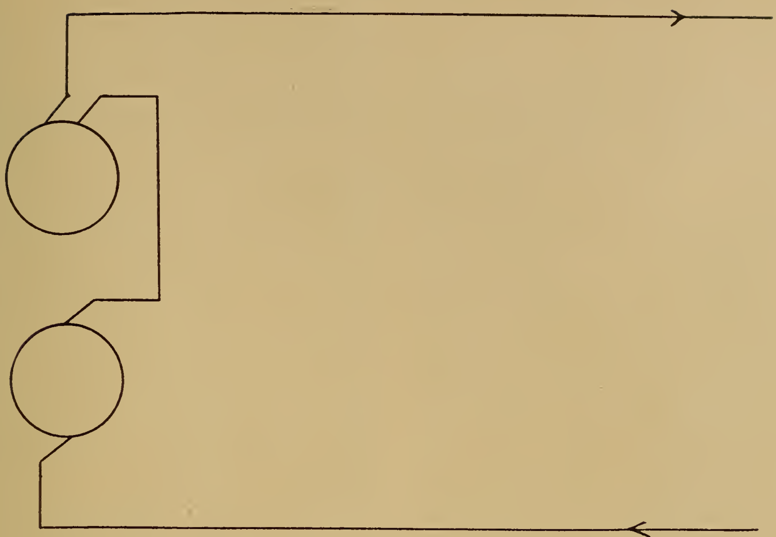

FIG. 11.—CONNECTION OF ALTERNATOR AND DIRECT-CURRENT DYNAMO

age on the feeder is zero. The conditions are suitable for producing a unidirectional voltage varying from zero to 1,000 volts at the feeder.

When there is an outside connection on the feeder, as there is when motors or lamps are connected, a certain amount of current is supplied by the two machines in series. The amount of current for any definite amount of power connected on this system varies from zero to a maximum with the variation of voltage. Moreover, the maximum current is greater than would be required for the same amount of power if it were connected on a direct-current system at 1,000 volts. When the alternator voltage is a positive maximum the current flows through the dynamo in normal direction. At the next half wave the dynamo generates no current. Since the current flows through the dynamo it causes heating of the conductors and contacts at brushes. The limit to the amount of heating permissible in the dynamo is determined by the constant direct current which may be allowed to pass through it. The current required for this pulsating system has a greater heating effect than the current required for a 1,000-volt constant direct-current system. The heating effect depends on the square of the instantaneous values of the current. An average of the squares of the instantaneous values of current is found greater than the square of the equivalant direct-constant current for the same amount of power. The result of this calculation when made for any particular load shows that a greater generator capacity is required for the combined system than for two direct-current generators connected in series. Consequently, the load can be supplied at least cost by two direct-current generators of the standard type connected in series. Besides the objection on the ground of increased capacity and cost, the combined alternating and direct-current system has the disadvantage of presenting abnormal conditions of commutation on the dynamo brushes, with consequent sparking.

As many difficulties are encountered in attempting to generate or rectify for the production of unidirectional or direct current, let us see what can be done with alternating current at very low frequencies. Low-frequency alternating current is nearly as desirable as direct current, so that if a generator can be perfected for producing

very low frequencies we have the desired result.

A frequency of five cycles per second gives good results when the losses are calculated for a very long transmission line. Alternators must have at least two poles. To obtain a frequency of five cycles per second with a two-pole machine the speed of revolution must be 300 revolutions per minute.

The motive power can be supplied by steam or water, depending on which is available. A Corliss type of reciprocating engine gives best results at speeds below 100 revolutions per minute. In fact, the speed adopted for very large units of this type is 75 revolutions per minute. This speed is suited to the driving of alternators at 5 cycles per second. The alternator would have eight poles instead of two for one-quarter two-pole speed.

Steam turbines are found to have less cost for installation and operation than Corliss engines for electric stations. These must be considered when determining the frequency. The great part of the saving derived from adopting turbines instead of reciprocating engines is due to their smaller size for equivalent rating. If we require such a slow speed as 300 revolutions, the maximum possible speed with types of generators now on the market when generating at a frequency of 5 cycles, the greater part of the advantage of the turbine is lost for the size approaches that of the older motors.

Hydraulic turbines give good results at the required speeds. However, the speed of this type of motive power is best adapted to a particular head of water-fall and the best results cannot be expected when the range of speed is set within such narrow limits as here proposed. The impulse wheels used with very high heads of water could not be adapted to this service and efficient results obtained.

The generators can be made for this low frequency. They would be of smaller diameter than the present types of machines and greater length as measured along the shaft. As for the economic utilization of material a comparison can be made with direct-current generators in so far as similar capacities of these machines are now made. There are no limitations of frequency and number of poles in the design of direct-current machines, so that we can fairly take them as representative of the most economical construction for the best utilization of material and labor. Broadly speaking, the direct-current generators and alternators for a frequency of 25 cycles have about the same ratio of length to diameter. We should, therefore, expect to find some disadvantage in adopting the very low frequency of 5 cycles.

The cost for transformers at this frequency would be enormous compared with present costs, so, even though a suitable generator and driving unit be obtained, the excessive amount of material necessary for the transformers would prohibit their use, probably.

A special type of generator has been proposed for generating low-frequency power. This is an adaptation of the induction motor with wound secondary for generator service. The secondary is excited by alternating current at a frequency lower than the natural frequency of rotation, thus giving a field rotating backwards with respect to the secondary and cutting the stationary winding at any speed selected. There is some question, however, whether the size of this generator is not much greater than would be required for normal frequency at an equivalent speed.

The conditions set forth above indicate that the electric apparatus has not reached perfection, as some would have us believe, and that there is ample room for improvement. My object in writing this article is to show what defects are now apparent in the present systems and to show the attempts that have been made to overcome these defects.

# ARTIFICIAL CONGESTION CENTRES IN CITIES

By Henry Harrison Suplee

THAT element in engineering work which may, for the lack of a better term, be called mental inertia is responsible for the perpetuation of many undesirable features in important undertakings which would hardly be possible if the subjects were approached with an entirely open mind, free from the impetus of irrelevant precedents. This fact is most forcibly evident when one considers the manner in which centers of human congestion are not only permitted to exist in many great cities, but are deliberately perpetuated in some of the most recent undertakings in the face of the existence of the most effective methods for their amelioration or abolishment.

The gregarious instinct in mankind inevitably leads to the dense population of large cities, and people naturally endeavour to go where people already are, but instead of endeavouring to control and moderate the consequent congestion, the engineer, of all men, often acts as if he were doing his best to render it worse by creating points of concentration in connection with the very works intended to relieve the pressure.

When steam railways were first developed nothing was more natural than that terminals should be designed as if the passengers upon alighting were desirous of continuing their progress in the same direction as that of the train. As a matter of fact, this was often the case, since the terminal stations were first placed in the outskirts of the larger cities, and further progress toward the center was generally necessary. Hence the accepted type of terminal took the form of a train shed of some sort, into one end of which the locomotive, with its cars behind it, entered, the passengers being permitted to alight upon platforms and proceed into a building at the other end, through which they passed into the street. Some noble structures of this kind resulted from the completion of the first great railways, and the pillars of Euston may be taken as a desire to emphasize this terminal idea, standing as they do in a sort of great open-air vestibule before the actual station itself.

The moderate amount of passenger travel rendered such terminal stations acceptable at first, and the tendency to imitate existing models caused them to be repeated upon various scales in different parts of the world, notwithstanding the fact that changing conditions might well have led to important modifications.

Stations, however, must be used by departing passengers as well as by those who are arriving, and soon it became necessary, with the existing agreement, to provide for the people who were coming as well as those who were going. Thus there developed, with increase of travel, conflicting currents of humanity and the confusion which necessarily accompanies the crowding of men, women, and children, with luggage, parcels, and impedimenta.

Instead of modifying the design and construction of railway stations in large cities to conform to the changing conditions, there appears, even yet, a tendency to continue on an ever-increasing scale the type of terminal which originated in the early days of railroading, and hence there exists in nearly every great

city a number of centers of congestion demanding continual improvement as the traffic increases, and forming obstructions which might to a great extent be relieved if undertaken in a different spirit.

The great railway terminal of today usually consists of two elements, a train shed and a "head house." Beyond the train shed is the "yard," a mass of tracks, necessarily arranged upon the "bottle-neck" principle, converging to the neck, or entrance to the shed, this latter being arranged to contain as many tracks as the site will permit, with long platforms upon which the passengers descend carrying their hand luggage, and along which they are compelled to plod sometimes for several hundred yards, often in the face of a similar opposing stream of humanity, only to find themselves at the end in a confusion of porters, cabs, street cars and bewilderment.

The departing passengers are congested in like manner, usually being confined in a "waiting room" until a comparatively short time before the departure of the train, and then filtered through a limited number of contracted openings to the platforms, along which they are compelled to walk until their places on the train can be found.

The locomotives and cars of which the trains are composed are also placed in a most inconvenient path for handling, since the train shed nearly always butts up against the "head house," requiring the cars to be drawn out and the engine slowly backed out after them, so that the bottle-neck entrance is compelled to do double duty, and is choked twice by each train.

The result of the entire arrangement is that a large amount of time is lost by the railroad, and a still larger amount by the passengers, to say nothing of the annoyances and personal inconveniences and irritation which necessarily follow such congestion. In addition to the confusion thus created within the station there is produced a state of congestion in the streets about the terminal, governed mainly by the activity of travel and increasing with the development of the place and the growth of business. Then, when the situation becomes practically unbearable, the place is torn down and rebuilt on a larger scale with a faithful repetition of all the defects.

Considering the subject from an independent viewpoint, let us assume for the moment that an engineer undertook to lay out a system of steam mains in a power house with a similar disregard for the fundamental principles of action. If the steam generated by a number of boilers were delivered into a contracted pipe of far less cross section than the sum of the supply pipes and also much smaller than the proper proportion for the engines, and if, in addition, the connections were so made as to cause, quite unnecessarily, a number of conflicting currents, we can imagine the adverse comments which such an arrangement would evoke.

Probably one of the worst examples of artificial congestion which could be cited is that existing at the New York end of the Brooklyn Bridge at the close of business hours each day. The great number of people occupied in the business buildings in the lower part of New York City and residing in Brooklyn throng to the contracted entrance to the bridge, crowding and struggling to reach the cars and behaving much the same as we may imagine particles of some fluid must do when compelled to pass through a sudden contraction in a channel. That such a congestion is almost wholly artificial appears when it is realized that the opening of the subway tunnels from New York to Brooklyn was attended with a general increase of traffic on the line, but with little or no concentration at any one point, simply because the passengers were able to board the trains at a number of stations along the route and not compelled to gather at a terminal of

necessarily limited accommodations.

The whole idea of a terminal, in the sense of a point where all the traffic is brought to an artificial stop, includes the production of an artificial congestion. Conversely, the remedy for this evil lies in the avoidance of dead stops so far as practicable, providing every means possible for the continuous flow of the human elements of which the crowds are composed.

This idea of continuity has been considered in a limited number of instances, but these are exceptions to the rule. Thus the great railway station at Cologne has a train shed above the street level and open at both ends, forming a "through" structure, the trains entering at one end and passing out at the other. The passengers enter below, at the street level, where are situated the ticket offices, baggage rooms and other offices, while numerous communications between the upper and lower floors render it possible for passengers to leave the platforms without being obliged to walk the entire length.

There are other cases in which the design of the station has been modified in accordance with modern requirements, but these are few compared to those containing within the plan the elements of artificial and unnecessary congestion. An excellent example of a special sort of station is that devised for the Hudson tunnels in the basement of the great office buildings which form the downtown station in New York City. In this case the station consists practically of a number of loops entering the building from one tunnel on one side and leaving to the other tunnel on the opposite side, thus serving a number of platforms, keeping the trains moving always in the same direction and maintaining a continuous flow of passengers, the station being served by elevators passing up through the buildings.

As a matter of fact, however, the terminal in the densely populated city is a center of wholly artificial congestion, the construction of which should be avoided altogether as much as possible. That this can be done is evident when we see how far it has been done in other lines of transportation. The extension of electric railways from local street service to suburban and interurban transport has not been accompanied by any demand for large terminals. On the contrary, every effort has been made to keep things moving on the road, passengers being taken up at any point in the built-up sections of the route, and high speed being made through the country districts. Yet in many cases these lines carry more passengers over distances quite as great as those included in the suburban service of the steam railways, a department to which much of the congestion at the present terminal stations is now due.

Apart from the inconveniences attending the congestion at terminal stations, much of the time consumed in a journey is due to the necessity of going to a station where the crowding and delays require a liberal allowance of time. If passengers could proceed to a local station within convenient distance of their homes as they now go to the local electric car line, the preliminary consumption of time would be greatly reduced and the distribution of the passengers would be effected automatically. This means that a number of local stations along the line of a railway within the city limits would be more desirable than a single big terminal, to which all must converge. The speed of trains within city boundaries is necessarily limited, and the time required for the traverse of the distance from the start to the open country would not be materially increased by providing, say, half a dozen stops in a city instead of a single point of departure, while the gain in time to the passenger by the greater convenience and proximity to his own starting point would really make the trip shorter to him in con-

sequence of the actual time saved.

This question of the actual time required by the individual passenger, while only indirectly connected with the matter of congestion, is an important one, since it bears upon the elimination of the congestion by the dispersion of the crowd. As a matter of fact, the passenger is interested in the time required for his own individual journey from start to finish, and he is desirous of doing whatever will reduce that time and also conduce to his own comfort while so doing. If he can save a material amount of time, taking into account that usually lost in the trip to the station, the sojourn in the waiting room, the tramp along the platform to the waiting train, etc., he is quite willing to allow a small fraction of this time to the train in its progress through the city and yet find his journey materially shortened. A similar advantage is experienced on arrival if the passenger can descend at a station near his destination, avoiding all the crush at the terminal, the long, crowded walk on the platform, the noisy cabmen, and the general confusion. A great part of the congestion is thus seen to be due to the existence of the terminal, compelling a mass of people to herd together regardless of their own desire simply because they are delivered into a contracted space when they might have been distributed over a wide area.

Following out the same principle of distribution as a remedy for congestion comes the suggestion of the separation of long-distance through traffic from local service. In a great city such as New York, for example, in which many thousands of people reside within a radius of about fifty miles, and travel daily to and from the business districts, a great proportion of the congestion arises from the inadequate terminal provision for such crowds.

The obvious remedy for this congestion is the abolition of the terminal for all such traffic, making the trains for this service a portion of the local transport system, passing over a continuous circuit in the city similar to that existing in the present electric-traction service, and making no terminal stop within the crowded district whatever. The use of a terminal station for the long-distance through trains would then be entirely permissible, since the time interval between such trains is sufficient to prevent crowding of the tracks and yards, while the relief caused by the absence of the thousands of local passengers would enable the people to be handled with ease and comfort.

That such changes can be accomplished in any brief period of time is not to be expected, but certainly it is to be hoped that sound engineering principles may in time be applied to the movement of human beings as well as to the molecules of inanimate fluids. The existence of centers of artificial congestion is to be deplored, and these centers can gradually be dispersed or modified, but in view of such object lessons of past errors of judgment it seems at least time that no new ones should be created, even at the loss of the imposing surroundings which they involve.

# THE RELIABILITY OF THE PRODUCER GAS PLANT

By Thomas L. White

THE first requisite in any machine is reliability, and especially is this true of prime movers. The heart of a factory is its power plant. When that stops the disco-ordination is absolute, and the chief consideration of the works manager when he is contemplating an engine to the comparatively untried producer gas-power plant should be concerned with the dependability of the new installation at all times under all conditions which are likely to occur in the normal routine of the day's work. A low fuel consumption is no doubt of the highest importance, but after all it is in practice a matter of dollars and cents, and may be more than offset by the loss incurred through repeated stand-bys for adjustments and repairs.

The question of reliability may be taken to cover—

(1) The regularity of the operation of the power plant when it is running at the normal load for which it was designed. What are the defects which are likely to develop from time to time?

(2) The regularity under conditions which so far as the needs of the factory are concerned are bound to arise from time to time, but which so far as the prime mover is concerned are a tax on its reserve powers—sudden changes of load, overload, underload, no load, etc.

(3) The character of the attendance which is required to keep the power plant in good running order and to cope with any disturbances in its functions which may be experienced. In other words, the human element.

(4) Can the average level of the performance of the plant viewed in the light of a coal economizer, and the fuel efficiency, which is the basic merit of the producer system, be depended on under ordinary working conditions where a certain latitude in the way of a departure from ideal test conditions must be conceded as inevitable?

Troubles in the operation of a producer power plant may have their origin in the generator or in the motor, or they may be due to a want of co-ordination in the apparatus as a whole, as when, for instance, the demand of the motor for gas is beyond the capacity of the generator to supply, and there is insufficient reaction between the fire and the gases passing through it. The class of difficulty which arises from the presence in the gas of tar and other impurities is not considered in this article, which is confined to the discussion of suction producers of moderate power constructed for the gasification of anthracite. The gas from such an apparatus can be continuously and reliably cleaned by scrubbing it in the ordinary washing tower.

The following quotations are from the record of a test made of a producer plant of this kind which was rated at 15 horse-power. The object of their appearance here is to exhibit, from the actual experiences of a six-days' run under skilled supervision, the character of the troubles which are encountered in operating a producer plant. Their selection from, as it were, between the lines of the report is in no way a disparagement of the particular installation in question, which showed considerable efficiency, and whose defects were large-

ly the necessary defects of the type of apparatus of which it was representative. This plant had been in daily use for some time to supply the power requirements of a small factory. It was especially overhauled for the purpose of the test.

*The First Day.*—The producer was blown up until the gas was good, and the test was therefore started at 7 A. M. with the engine under load. After running a few minutes, however, the engine stopped, and it was found that the point of ignition was wrong; the engine was firing too late to carry the full load. Considerable time was spent in making the adjustment, and it was 1:30 P. M. before a second attempt to start was made.

*The Second Day.*—Upon arrival at the plant at 6:30 A. M. the fire was found to be rather low. The compressed air was turned on for a few minutes in order to liven up the fuel column; the generator was then poked down from the top through the poke holes and the ashes were raked from the bottom of the producer, together with some clinker which had formed during the night; the air was then put on and kept on till 7:45 A. M., when the gas was sufficiently good to start the engine.

*The Third Day.*—The blast was put on at 7 A. M., and the gas was good enough for starting at 7:20 A. M. The engine was started up with about 14 horse-power, but after it had been running for a period of about two or three minutes it stopped, due to premature ignition. The point of ignition was changed to suit, and a fresh start was made.

Quite a number of difficulties were encountered in starting on the morning of this day, and a final examination showed that the igniter points were in bad shape and that the points needed to be replaced. The real test of the day started at 9 A. M.

*The Fourth Day.*—No adjustments were necessary.

*The Fifth Day.*—It was evident that the valves did not stay in place during the day, and had to be readjusted from time to time on this account. They had, moreover, to be adjusted whenever the load on the engine was changed to any extent.

When the fire was drawn on the morning after the trials a considerable amount of clinker was discovered on the sides of the generator. On raking out the ashes each day it was found that even when the greatest care was exercised some of the unburned coal escaped from the generator at the same time. It may be mentioned that the valves with which trouble was experienced were the two controlling respectively the air admission to the vaporizer and the air admission to the motor. The main operation of the producer was excellent, the gas supplied to the engine being of good quality under all conditions of load. The fuel consumption was satisfactory.

From the reliability point of view the noticeable feature of these runs was the time spent on adjustments about an apparatus which had just been overhauled expressly for the purpose of the test, and which was presumedly in first-class shape. Moreover, the trouble was such as to call for experienced attention to diagnose it. Further, what is important, it was of the kind which would be likely to occur at any time in the same or a similar apparatus.

The fact is that a producer power plant can in no sense be regarded as automatic as the term is usually applied to machinery. It is true that long runs have been made without serious interruption when a uniform load was maintained which did not differ very much from the rated horse-power, but even if it is conceded that such performances are the rule, rather than the exception, it is still true that the various factors which enter into the question of the reliability of such installations are more complex and more uncertain than in the case of steam plants. No less than three distinct chemical operations must occur in the cycle of a

producer before the energy of the fuel is delivered in useful work at the crankshaft, and for this reason the control can never have the positive character which is realized in the steam engine. This defect is innate in the operation of the apparatus considered as a unit and in the operation of its two essential parts considered individually. Thus the generator is not like a boiler, merely a container, where a physical change from the liquid to the gaseous state is effected, but the seat of a continuous chemical transformation in two stages, and the motor is not only an instrument for converting the heat energy of an expanding fluid into work, but a mixer and a combustion chamber as well. The practical point is that where there is such complexity of function it is difficult when trouble arises to locate the cause of it. The motor suddenly refuses to carry the load. What is the reason? It may be that the fuel column is creeping on account of the formation of clinker. It may be that the vaporizer is not supplying the proper proportion of steam to the in-going air. Perhaps there has developed an air leak in the wall of the generator or its connections. Or, the origin of the trouble may be in the motor itself, a foul spark plug, badly timed ignition, a wrongly set valve, or a loss of compression. Of course, some of these and similar difficulties would be of comparatively rare occurrence in a well-designed plant, but even at that it would seem as though the class of labour which is needed around a producer plant must at least be as intelligent and as skillful as is needed in the case of steam. The idea that it is only necessary for the manager's gardener to stroll over once in a while and poke the fire in the generator is a vanished illusion.

A canvass of the leading manufacturers of producers was made by the author, with a view of ascertaining their views on this question of labour for producer plants, and the majority of the replies were virtually a repetition in varying form of the following typical answer:

"Labour can be figured as practically the same as in a steam plant. As to the class of labour necessary, a man who would make a good steam engineer would also make a good gas engineer, but he should be a man who is willing to learn. An old steam engineer is generally averse to putting in the necessary amount of study and work needed to fit him for running a gas plant."

As representing the power consumer's point of view, the following is the experience of a firm who installed a producer to supply power for all purposes, pumping, drilling, lighting, etc., in connection with the operation of a mine:

"We have found no difficulty whatever running the plant. Any mechanically minded man who is capable of taking in things can, with two or three weeks' instructions, operate a producer plant without any trouble. We secured the services of two young men, one of them a marine engineer; the other a young fellow who had run a set of pumps and a hoist in a mine. These men took a course of instruction from the engineer who installed the plant, as did my brother and myself, and any of us can operate the plant without the slightest trouble."

Another power user who had installed a 30-horse-power gas plant said: "I find very few engineers who know anything about producer gas plants, and therefore the scarcity of skilled labour of that kind is one of the problems which we have to consider in installing a plant of that kind."

Generally speaking, both as regards the intrinsic dependability of the new system in itself and as regards the study necessary to operate it, there is a danger in changing over from steam to producer gas, of taking too much for granted. Sound information about the nature and operation of the steam engine is so widely disseminated that one is apt to for-

get that in the case of the producer gas plant no such general level of intelligence exists. The practical course is for every power consumer who decides to install such an apparatus to insist on the manufacturer of the plant which he selects not only giving the necessary education to the engineer who will have the running of it, but also a guarantee that with a man in charge so trained by themselves the installation will do the work for which it is designed.

It is a merit of the suction producer plant of moderate capacity that not only is it as economical in coal consumption as a larger installation, but that as constructed at the present day it is probably as efficient in this respect as it ever will be. The replacement of the steam engine by the explosion motor burning producer gas will therefore abolish a serious handicap under which the small manufacturer labours at the present moment in comparison with his big competitor. It is not a practical proposition to install a compound condensing Corliss engine where only moderate powers are required. It is not "an economical piece of apparatus," and the small user of steam power is thus condemned to produce his power in a relatively inefficient manner, every horse-power costing him twice, and even three times, the amount of coal that would be expended in a large up-to-date steam plant. Now, in gas-engine practice efficiency does not depend on a number of complicated extensions of the main principles of the engine, but on the degree to which the charge is compressed before ignition, and it is just as easy to build a small motor which will hold a high compression as a large one. It follows that a general adoption of the producer system would place all power plants on very much the same basis of efficiency.

The cardinal merit of the producer, its fuel economy, is fortunately largely independent of the personal equation as represented by the incompetence or negligence of the stoker. In firing boilers, the coal consumption depends to a great extent on the skill with which the fresh fuel is spread over the surface of the fire. In replenishing the generator of a producer plant there is no such opportunity for the display of skill or the want of it. It is only in the operations of poking down the fires and removing the ashes that even moderate care must be exercised. If the fuel consumption of a producer plant is higher than it should be the cause must normally be sought in the state of the generator, the motor, and their accessories, and in the conditions under which the plant is being operated.

If we define the present status of the producer gas plant as one of proven efficiency and partially proven reliability, the character of the attendance being in each case a determining factor, it would seem as if there could hardly be two opinions as to the advisability of the small factory changing over to the new system. To quote the words of the report of the Technologic Branch of the United States Geological Survey: "The end of the steam engine is nearly in sight," and that being so, "why hesitate?" The answer is that among the *pros* and *cons* on which a decision must be based the same old question of reliability crops up in a different form.

To make this clear, let us consider for a moment the analogous case presented by the history of the automobile industry. In the early nineties the horseless vehicle as an American product did not exist. When the boom came, and factories sprang up as plentifully as mushrooms, the aim of each designer seemed to be to give full rein to his own idiosyncracies with a view to the production of a car differing radically from the car put out by his competitor. After being tested out, generally at the expense of the luckless purchaser, the freak features became rarer and rarer, and in its es-

sential features automobile design became standardized. Moreover, it was a fact that, although the construction of automobiles was fairly well advanced in Europe before it was undertaken on this side, still, owing to a difference in the conditions to be met, the art here developed along lines which were in some ways independent of precedent. In the matter of producer plants we have had, and are having, an almost similar experience. Much of the early apparatus put out since 1903, when the industry can be said to have taken root in the States, was of bad design, and the same is probably true of some of the plants which are now on the market. The works manager must therefore consider whether in making the inevitable change at once he is not running the risk of buying experience for someone else to profit by. Would it not be safer to wait until gas producer design becomes more standardized and the new system consequently more reliable?

If we were speaking now of the larger type of producer designed for the combustion of bituminous and sub-bituminous fuel the writer would be inclined to advise Fabian tactics. The character of these coals as mined in America is distinctive, and the producer which will successfully gasify them must be developed to suit indigenous conditions which are not paralleled in Europe. In the case of anthracite, however, we have a fuel which is fairly uniform in character the world over, and European experience in its use in producers is practically the basis of the art in America. In other words, there is already some approach to standardization in design in the product of the chief makers, and, what is of practical importance, there are now engaged in the manufacture of suction producers for the use of anthracite a number of firms of such standing that their guarantee given with their product may be regarded as an effective protection. This the purchaser should be careful to obtain, the guaranteed performance having special reference to the normal needs in the way of power of the plant in which the producer is to be installed. There is little to recommend the example of the owner of a grist mill who installed a producer plant to supply light power for two or three hours on alternate days.

It has been assumed so far in this article that the only practical fuel for the small suction producer is anthracite, and so far as available apparatus is concerned this supposition is a correct one. However, since the government tests at St. Louis showed that coals of such low grade that they are even unfit for use under boilers can be successfully gasified, a number of firms have been engaged on the task of turning out an apparatus in which the cheapest fuel can be used. The writer has by him more than one letter in which the manufacturer claims by the use of the down draught or the mechanical separator to have thoroughly solved the problem of extracting the tar and other impurities with which the gas from low-grade fuels is always contaminated. In one or two instances the manufacturers state that they are unable to cope with the orders in hand for producers of this kind, and that, pending factory extensions, they are not courting publicity.

The significance of this development from the point of view of the small power user is the possibility it offers of the use of a cheap coal in the future, for there is no apparent reason against the construction in time of small producers for the use of bituminous fuel. It is doubtful, however, whether the complication of mechanism necessary to deal with the tar would be either practical or profitable in small units, and there is the further consideration that a small plant should require a minimum of attention and that a loss of simplicity is, so far as reliability is concerned, a step in the wrong direction.

Producer plants work best under a

uniform load condition, and it has been suggested that the best solution of the power question for the small shop would be along co-operative lines, a central generating station being erected for the supply of power to a group of three or four plants. It would not be difficult to make the resources of such a station sufficiently elastic to meet all power demands that could arise, and if equipped with a large and a small producer installation, which could when necessity arose be run in parallel, an economical load could practically be maintained all the time.

# THE ORIENT AS A MARKET FOR MOTOR ENGINES

By W. G. Winterburn, M. I. N. A.

MANUFACTURERS of gasoline engines searching for new outlets for their products have frequently asked the writer what prospects exist for building up a business in far Eastern countries.

There are several causes tending to retard the general use of explosive engines in that part of the world, but the field is vast and the hindrances will gradually be eliminated, though perhaps too slowly to greatly benefit the present generation of manufacturers: yet in these days of kaleidoscopic changes in the order of things Oriental, one never knows what the morrow may bring forth, therefore a knowledge of conditions which obtain now may prove useful.

China is destined to become the great mart for mechanical productions of the immediate future, but as its territory covers 25 degrees of latitude, for the purpose of this article it is necessary to divide it and include the southern, or tropical, portion with the Philippines, Indo-China, and the Malay peninsula.

In those countries it is found that the cost of highly volatile fuel is too great to permit the extensive use of explosive engines; the freight rate of "dangerous goods" to tropical lands is very high; marine insurance almost prohibitive, and the restrictions imposed by the governments on the handling and storage are irksome and expensive to dealers. In addition, there are the customs duty in the French colonies of Annam, Cambodia, and Cochin China, and in the United States Philippines.

For commercial purposes, then, the gasoline engine has little chance of supplanting steam south of the Tropic of Cancer. The native is notoriously regardless of the dangers of fire, and what the authorities leave undone in deterring the use of light oil fuels the insurance companies complete, consequently the market for such is practically restricted to automobiles, and, as the demand for these will always remain small, not much decrease in the price of gasoline can be looked for.

Contrary to popular belief, the white population in tropical lands is not as a class rolling in wealth; the cost of periodical trips home, keeping an army of servants, and the maintenance of the essential style, absorbs any revenue which is not princely. A carriage and pair can be purchased for much less than an automobile, and a *syce* who thoroughly understands horses can be had anywhere, but it is difficult to find a native chauffeur who can adjust a carburetor. Electrical devices are difficult to keep in order in the steaming heat of the tropics. Dry cells soon perish; tools and gear are always rusty, and when repairs are required and an expensive European engineer is called in he mostly has to experiment to discover the defect, and often leaves the machine worse than he found it.

Similarly for marine motors, although there are motors advertised at prices which would land them in Singapore for less than a quarter of the cost of equal power steam machinery, the subsequent advantages of the latter more than counterbalance the difference in first cost. Native mechanics can dissect and put together again a steam engine, and it will work, within limits, even if not

properly adjusted; boilers are under government supervision, and an explosion is never heard of, and, although two men are required where one would suffice if a motor was used, wages are low enough to let that consideration be negligible.

From the foregoing it will be seen that the class of internal-combustion engine suitable for those climes is one burning heavier oils, preferably ordinary lighting kerosene, which is procurable everywhere. Some successful ones are in use, mostly of Dutch make, but they burn a good deal of oil, and, on the whole, steam is likely to hold sway for a considerable time yet.

Taking the China coast northward from Amoy, and including Manchuria, Corea, and Japan, there should develop an enormous trade in motor engines. In Japan the field is illimitable; but as it is a somewhat difficult country to do business in, owing to protective methods, the imitative manufacturer, and disinclination to encourage foreign importations, a really lucrative trade would be hard to establish. Nevertheless, a certain amount would eventuate the inevitable fac-simile of any motor whose success had been demonstrated would soon appear, and the only protection would be to see that a trade-mark had been properly registered; then to watch that the trade-mark was not copied also. As Japan does not yet produce cheap drop-forgings and steel castings of the required resiliency, nor cast iron exactly suited for resisting continuous explosions, and, in any case, would have to import coils, plugs, carburetors, and dry cells, enterprising manufacturers have some chance of success in that archipelago.

Shanghai is the best center to work from; the network of waterways extends for hundreds of miles, and the use of towing and passenger launches is growing daily. The traffic on the rivers and canals is enormous, and as Shanghai is nearly a free port—5 per cent. duty ad val.—the cost of motors delivered there would not be excessive, and stocks of engines and parts maintained would not mean heavy outlay of capital.

From Shanghai as nucleus, business would extend to other treaty ports when it became known that spare parts and skilled overhauling could be had in the vicinity. It would be essential that the agent handling the goods be himself an expert; then it would be easy to train Cantonese mechanics to do the work; also he should possess that faculty of being able to deal with Asiatics which can only be described under the phrenological title of "human nature." Climatic conditions are favorable, and a live firm of manufacturers should be able to make Shanghai a very important feeder of their business.

# Current Topics

THE extent and activity of the interest existing in connection with the subject of gas power, in the United States at least, are indicated by the progress which is being made by the gas-power section of the American Society of Mechanical Engineers. The desirability of organizing such a section appeared less than a year ago, and at the summer meeting of the society at Detroit the sessions of the section attracted some of the largest attendance of the convention. A study of the scope of work appropriate for the section has shown such a wide range of activity that the committees having the subject in charge are convinced that there is ample reason for holding several meetings during the course of the year.

This whole subject of the scope of study and research suitable for the work of the gas-power section will come up for discussion at a meeting of the section to be held in the Engineering building in New York this month, and we are convinced that it will reveal a far wider field than has hitherto been appreciated.

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IN some quarters there has appeared a tendency to consider the internal-combustion motor as a rival to the steam engine in the sense that one machine is destined to supplant the other. The mistake of this view is apparent if we consider the history of other departments of technical development and realize how each subject creates its own field and markets, by the side of those previously in existence. Electric lighting has not displaced gas, but rather stimulated improvements which have vastly developed the fields for both systems. Steam has grown up side by side with hydraulic power, and both are valued and active servants of mankind.

So far as the gas engine is concerned, it is beginning to be realized that for very large units, in which all the modern methods of attaining efficiency are practicable, the steam plant can generate power at a cost which leaves little or no margin for successful rivalry by the gas engine.

The principal field for the large gas engine at the present time appears to be in connection with the utilization of waste furnace gases, rather than with independent producer plants. When we come to engines of moderate size, however, the real commercial field of the gas engine appears, since it is in this department of power production that the economy of the steam engine falls off, while that of the gas engine remains almost, if not quite, as high as in the larger sizes. For the small power plant in which

the suction producer can be combined with the engine to form a complete unit the fuel economy is far ahead of anything that can be attained with a steam plant of the same power, and in this very large market there is abundant opportunity for commercial development and for the extension of power machinery in many minor industries.

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THE remarkable work which has been accomplished during the past month by the Wright brothers, both in America and in France, is drawing renewed attention to the possibilities of the aeroplane. As we have already remarked in these columns, these indefatigable experimenters have qualified themselves especially for their work by their years of practice in gliding flight, using planes of various forms and experimenting with steering devices, so that when a motor of sufficiently light weight per unit of power became available its application to their work naturally followed. With the records which have already been made, extending over distances of thirty to forty miles and lasting for more than an hour continuously in the air, the success of the aeroplane must be conceded by all, and its future development considered only a matter of time.

It is probable that an early field for the development of the aeroplane will be for sporting purposes, and that its progress will follow somewhat along the same lines as that of the automobile. At the present time, however, the cost of the machine is such as to preclude any idea of widespread popularity, but experience has shown that standardization and competition can do much in reducing costs, and such modern methods of manufacture will doubtless gradually be applied to aeroplane construction.

The deplorable accident at Fort Myer has only emphasized the fact that it is constructive details alone which need to be perfected, including materials of the highest grade and proportions accurately computed.

ORDINARILY in depositing copper electrolytically only about 30 amperes per square foot of depositing surface could be employed even when an agate burnisher was used, and this burnisher is needful to prevent the deposit taking a nodular form. Mr. Cowper Coles found when carrying out certain experiments of deposition by rotating methods that a current density of as much as 200 amperes per square foot could be employed if the rotation speed was greatly increased; the product was smooth on the surface and the copper had a tenacity as much as 50 per cent. above that of ordinary cast and rolled copper, the strength increasing with the speed of the mandrel.

The best or critical speed of rotation was found experimentally by rotating cones, the speed being calculated from that part of the cone where the deposit remained smooth. Experiment showed that the current density of 200 amperes was on the whole best, though 500 could be used if a still higher speed of rotation was employed, but the increased voltage necessary to drive so much current through renders any density above 200 undesirable.

Annular vats are employed, so that there are no working parts in the vats, and copper sheets can thus be made 20 feet by 5 feet—a sheet being simply a cylinder cut and laid flat. About 0.8 volts is sufficient. The rotation keeps the electrolyte agitated and even in quality, and the particles of deposited copper appear to be rubbed down by the skin friction. Air bubbles are removed, which would cause nodules to form, and the deposit is made of even thickness even for an 8-foot long mandrel.

The process is started by first depositing copper on a mandrel slightly less than the finished internal diameter of the tube wanted, from an alkaline solution, then thickening it up in an acid solution and highly burnishing the surface. This prepared mandrel is then placed in the depositing vat, and when it is of required diame-

ter, i. e., when the coating is thick enough, it is put into a lathe and rotated against a round-faced roller, which expands the deposited copper so that it can be drawn off the mandrel. Copper sheets are made by inserting a narrow insulating strip, which enables the sheet to be easily parted and removed. Thin sheet is as cheap as heavy sheet to make.

Copper wire is deposited as sheet upon a mandrel around which is cut a spiral scratch of such pitch as corresponds with the wire to be made. This scratch causes a fault or cleavage plane in the deposited sheet, and the wire readily parts along this line as it is wound off with a sideways pull, after which it is drawn to shape through dies. As many as four or five miles can thus be obtained in one operation.

It is anticipated by the author that the day is not far distant when copper will be leached direct from the ore and electrolytically manufactured without any intermediate smelting and refining processes. In this centrifugal process there is very little copper locked up for a given output as compared with other processes. Electrolytic copper is 99.9765 per cent. pure. The cost of production is less than three pounds per ton.

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MR. THOS. HUMPAGE read an interesting paper on the evolution of spur gearing before the July meeting at Bristol of the Institution of Mechanical Engineers, tracing the spur wheel from its earliest days. A sample of early spur gearing may be seen at South Kensington in two or three old clocks, notably that which was once at Glastonbury Abbey, having been made by a monk, one Peter Lightfoot, about the year 1335. This clock worked at the Abbey until the dissolution of the monastery, when it was removed to Wells Cathedral, whence it was, when worn out, brought to South Kensington. The clock ran 500 years, and is running yet. Another clock there is that from Dover Castle, and one of similar make is at work yet at Rye Church, and the writer has seen one very similar in the museum at Dinan, in Brittany, and doubtless there are many very old samples of spur gears in old English churches in some of the country villages.

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IF the estimate is correct that fifteen million tons of coal are annually carbonized in the gas works of Great Britain it is clear that gas making must be a big industry, and Mr. William Stagg's paper at the Bristol meeting of the Institution of Mechanical Engineers, on coal and coke-handling plant for inclined retorts, comes apropos of the recent Mining Exhibition, where coal conveyors proved a very important part of the show.

The Bristol retorts are inclined, and gravity is the force which assists so materially both to discharge and charge the retorts. Inclined retorts are not new, for Murdoch himself used them at the beginning of last century. Inclined retorts are not, perhaps, perfect, for their inclination cannot be right for all sizes of coal. Still, they work with fair satisfaction. They are made gradually larger towards their lower ends, so that the finished charge may more easily slip out of the retort. It is generally understood that the size of coal has a good deal to do with the satisfactory working or the reverse of inclined retorts, so that, as was once suggested, perhaps jocularly, the whole bench ought to be built on a foundation plate capable of being placed at any required angle, so as to accommodate the slope of the retorts to the nature of the coal. The author of the paper, however, appears to think that the progress of the inclined retort has been merely retarded by the success of coal projectors and ram dischargers, since these machines will discharge from one side only of the retort house. But he also recognizes the need for more careful choice of coal where inclined retorts are used. Ideal coal is

1¼-inch nuts. Smaller coal, especially if damp, requires a steeper angle; larger coal a flatter angle. The angle decided on at Bristol was 31 degrees.

About 6½ to 7 hundred-weight are charged into a retort, and twenty retorts can be drawn and charged in twenty-five minutes, the retort lids being machined and closed by an eccentric shank lever. It is added that, owing to the regular heat that can be maintained, one bank of retorts at the Avon street works has been in continuous work since August, 1904, never having once been let down.

Altogether this is a very useful and interesting paper, and gives an excellent idea of the procedure in a retort house on this modern system of inclined retorts.

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When does a strut of a certain ratio of length to diameter begin to buckle? This is the problem sought to be solved in the tests described by Mr. C. A. M. Smith in his paper before the Institution of Mechanical Engineers.

Euler's theory of column resistance is based on the assumption that under some critical load $P$, the column, is in equilibrium. Increase $P$ and bending will increase; reduce $P$ and the column will straighten out. This means that any load which will cause deflection of a column must ultimately break it. Within reason and limits this is true.

The author's method of showing the behaviour of a stressed specimen was to attach to it at some distance apart a pair of brackets by three set screws 120 degrees apart. Each of these pieces or carriers carries three separate twisted strips of steel with a mirror at its central point, the strips being twisted in opposite ways on opposite sides from the mirrors. Thus, if a specimen lengthens this is shown by the twisting of the strips, and the angle of torsion is multiplied by the weightless lever, a reflected beam of light.

If a specimen bends under stress the three light spots will not move equally. The instrument is called the sphingometer, and appears to have a useful field, for little is really known of column resistance, as proved by the failure of the Quebec bridge.

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In a paper recently presented before the New York Railroad Club, Mr. R. Emerson brought out some interesting points in connection with the reduction of operative railway costs. The discussion hitherto actively carried on in railway circles in the United States has assumed that commercial success could be attained only by effecting one or the other of two changes: the raising of freight rates or the reduction of wages. To many men, however, it seems as if there were other questions to be considered, and possibly some more desirable method of causing the balance to appear on the right side. There is no doubt that business has fallen off, while maintenance and fixed charges go on, and the result is that dividends are threatened, and even fixed charges endangered, and all are agreed that something ought to be done.

This something, according to Mr. Emerson, is to be found in the improvement of the efficiency of labour and the development in economy of material. The special topic selected by Mr. Emerson is that of locomotive supplies, a matter which has been overlooked in many cases, and one in which serious wastes may easily occur. A list of supplies required for road locomotives would number several hundred items, and one immediate source of economy in this respect appears in standardizing such a list, with due allowance for flexibility to meet variations in service. The magnitude of this task appears when it is asserted that an effective standardization must extend over a period of many months, being a grad-

ual process, replacing old articles by others in some instances, while some tools and parts may be made standard at once. The cost of such standardization is estimated by Mr. Emerson as capable of being fully repaid inside of three years, owing to greater ease of supervision, besides the actual economy effected. On most roads it is believed that such a change would pay for itself in two years, and in actual practice, where the process is a gradual and continuous one, the cost of the change would never be felt, the mere fact that efficient supervision of the supplies was being exercised causing greater economies than those resulting directly from the standardization itself.

The paper gives a tabulation of expenses for supplies for locomotives on a number of the leading railroads in the United States, showing that in nearly every case the cost is double what it should be, while in some cases it might be reduced to one-third what it now is, including the actual expenses of supervision. The actual savings possible by the proper standardization and efficient supervision of locomotive supplies is estimated at $10,000 a year, in the case of a railroad operating only 200 locomotives, while it might reach as much as $200,000 per year in the case of a railroad system as large as that of the Pennsylvania.

Similar methods can be applied to other departments of railroad operation, and in some systems such methods have gradually been put into operation during the past five or six years. The tabulated figures for one American railroad show that a systematic supervision of shop equipments, for instance, operating from 1,300 to 1,800 locomotives, has been instrumental in reducing the cost for maintenance, tools, and machinery from $307 per engine to $156, practically cutting this expense item in two. It is by such methods, rather than by raising rates or lowering wages, that dividends may be earned for the stockholders, methods which should appeal to engineer and manager alike.

# WILLIAM R. RONEY, M. Am. Soc. M. E.

A BIOGRAPHICAL SKETCH

THE development of the modern power house has brought with it a number of problems, among which one of the most important is the successful handling and combustion of great quantities of fuel. The result has been the production of mechanical appliances, not only for the handling and delivery of the coal and the removal of the ashes, but also for the firing of the boilers, and in by far the great majority of the power houses of America and Europe some form of mechanical stoker has replaced the older method of hand firing. The Roney stoker, a most successful and effective device for replacing hand labour, has done much to make the name of its inventor known, but the subject of our sketch, Mr. William R. Roney, has been active in other important fields of engineering work as well.

William R. Roney was born in 1849, at Hamilton, Ohio, and received his education at Shurtleff College, Upper Alton, Ill., and at the University of Chicago. For thirty-two years he has been engaged in mining and metallurgical work and in the practice of mechanical engineering, having built and operated smelting and refining works for the treatment of silver-lead and copper ores in various parts of the United States and Mexico.

During the past twenty-three years Mr. Roney has been actively occupied in mechanical engineering work, especially pertaining to power-station design and to the economical combustion of fuel and the efficient operation of steam generating plants. His work in this department of engineering includes the design and installation of the first boiler plant in the United States to be operated with induced draft; also the invention of an improved form of circulating economizer for heating feed-water from the waste heat of the flue gases, and the invention of the Roney mechanical stoker, for use with all varieties of bituminous, lignite, and anthracite coals. More than one and a half million horse-power of steam boilers in the United States, England, France, Canada, Mexico, Japan, and South Africa have been equipped with this stoker, including most of the great electric lighting and power stations in various parts of the United States.

Mr. Roney is interested in a number of American and English mining companies operating in the United States and Mexico. He is a member of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institution for the Advancement of Science, the Franklin Institute, and the American Geographical Society, and he has contributed several papers to their transactions and to the technical press.

# Manufacturing News

### Alcohol Fuel in Combustion Engines

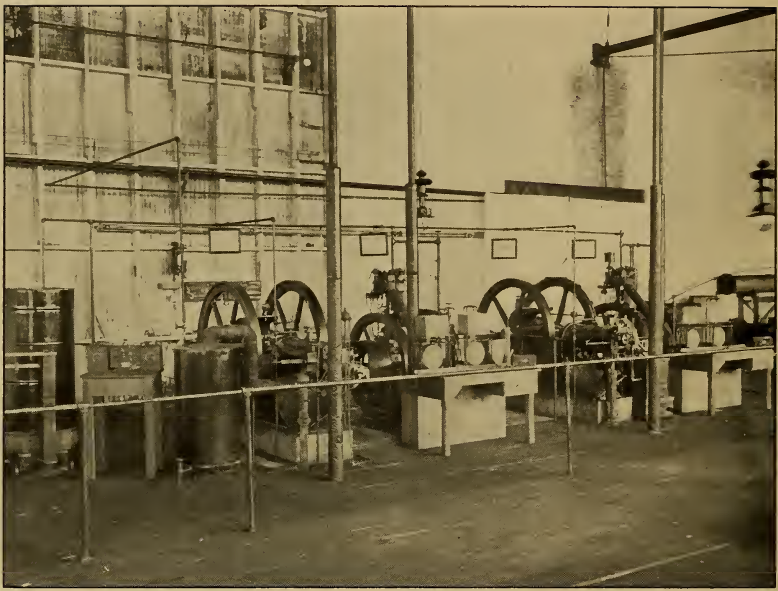
IN view of the numerous and somewhat conflicting statements as to the relative values of gasoline and denatured alcohol as fuels for internal-combustion engines, the report of the Technologic Branch of the United States Geological Survey, containing the results of more than two thousand tests, will be welcomed. These investigations, conducted under the direction of Mr. J. A. Holmes, represent the most complete investigation of the kind which has been made in any country, and, as such, are to be accepted as authoritative. The general conduct of the tests was in charge of Professor R. H. Fernald, with whom was associated Mr. R. H. Strong, assisted by a corps of specially trained men. The investigations form a part of the valuable work of the Fuel Testing Board, and were conducted at the plant at Norfolk, Va., and the intention of the work was to show the comparative fuel consumption of gasoline and 73 per cent. specific gravity and commercially denatured alcohol per unit of power.

Broadly, the results of the tests proved that the consumption of the two fuels is the same, *by volume,* when each is used in an engine so designed and operated as to present the most advantageous conditions. The average consumption obtained from many tests is eight-tenths of a pint of either gasoline or alcohol per brake-horse-power per hour. These results cannot be obtained by using alcohol in an engine arranged to use gasoline to the best advantage, neither will gasoline do so well in a motor designed and adjusted for alcohol, and each machine should be adapted to its appropriate fuel.

Considering that the heat value of a gallon of the denatured alcohol is only a little over six-tenths (0.6) that of a gallon of the gasoline, this result of equal fuel consumption by volume for gasoline and alcohol engines probably represents the best comparative value that can be obtained for alcohol at the present time, as is also indicated by Continental practice. Though the possibility of obtaining this condition in practice here has been thoroughly demonstrated at the government fuel-testing plant, it yet remains with the engine manufacturers to make the "equal fuel consumption by volume" a commercial basis of comparison.

The gasoline engines that were used in these tests are representative of the standard American stationary engine types, rating at 10 to 15 horsepower, at speeds of from 250 to 300 revolutions per minute, while the alcohol engines were of similar construction and identical in size with the gasoline engines.

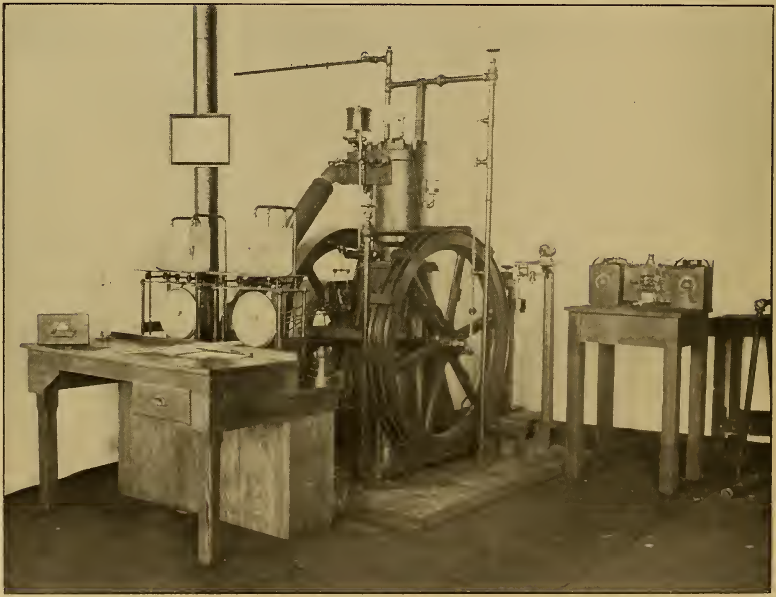
The commercial completely denatured alcohol referred to is 100 parts ethyl alcohol plus 10 parts methyl alcohol plus ½ of 1 part benzol, and corresponds very closely to 94



GASOLINE AND ALCOHOL MOTORS UNDER TEST BY THE UNITED STATES GEOLOGICAL SURVEY

per cent., by volume, or 91 per cent. by weight ethyl alcohol (grain alcohol).

The tests showed that, with suitable compression, a thermal efficiency of 34.6 per cent. was obtained with alcohol, a result approximating that reached in the Diesel motor with the heavier hydrocarbons, while the highest thermal efficiency attained



TEN HORSE-POWER ALCOHOL ENGINE USED IN THE TESTS OF THE UNITED STATES GEOLOGICAL SURVEY

with gasoline was 22.2 per cent., values ranging between these being obtained from mixtures of the two fuels. These efficiencies refer to the brake-horse-power and the lower calorific values of the fuels, the heating value of the gasoline being 19,100 B. T. U. per pound and that of the alcohol 10,500 B. T. U. per pound.

The results heretofore given out regarding the value of alcohol as a fuel for internal-combustion motors have been obtained in many cases from engines intended for gasoline, and under such conditions from one and one-half to twice as much alcohol is required as gasoline for the same power. The tests of the Geological Survev indicate that it is impracticable to alter a gasoline engine so as to secure the best results with alcohol, since the arrangement of cylinder heads and valves does not permit the best compression, nor are the engines strong enough to stand the explosive pressures, these latter often reaching six to seven hundred pounds per square inch. Since the increased weight of the alcohol engine over the gasoline engine is accompanied by a corresponding increase in power, the weight per horse-power remains about the same for both engines, regardless of the fuel used.

Since the fuel consumption by volume is about the same for both fuels, it follows that the power cost is a function principally of the relative costs of the two fuels. This means, however, that the builders of combustion motors must be looked to to place on the market engines originally designed for use with alcohol, and not attempt to offer slightly modified gasoline engines for such service. A mere increase in compression by reducing the clearance space is only a makeshift, and one which cannot be expected to give the best results of which alcohol is capable, results which have been positively demonstrated by the tests of the Geological Survey.

### Incandescent Lamp Manufacture

IN order to provide for the very heavy demand for Edison lamps, and to take care of the new developments in GEM, Tantalum and Tungsten lamps the General Electric Company have, in the past year, built four new factories at East Boston, Toledo, Ohio; Fort Wayne, Ind., and Newark, N. J.

The factory at Toledo is confined to the production of the GEM filament lamps only; that of the Newark factory to Tungsten lamps only, and the factories at East Boston and Fort Wayne to the regular carbon filament lamps. In addition, the General Electric Company has erected a new factory building at Harrison, N. J., adjoining the present lamp factory, which is devoted to the production of Tungsten lamps.

In addition to these new factories, the main factory at Harrison, N. J., continues its large output of carbon and GEM filament lamps. The total productive facilities of the General Electric Company now aggregate sixty million lamps per year, so that they are in excellent position to supply all demands from customers.

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### The Sewage Pumping Stations at Dayton, Ohio

THE city of Dayton lies in a valley surrounded by hills whose slopes drain very rapidly. At this point several streams unite to form the Great Miami river. This stream in summer is of insignificant proportions; but in late winter and early spring, after a sudden rain or melting snow, it rises in a few hours to the proportions of a great river. To protect the city from inundation, levees are maintained; but a rise in the river cuts off the sewers, and it is necessary to close the gates at the outfalls to prevent the river backing up into the streets and houses. At such times it is necessary to raise the sewage and discharge above the flood level. After careful investigation and some costly and unfortunate experiments with steam pumps and

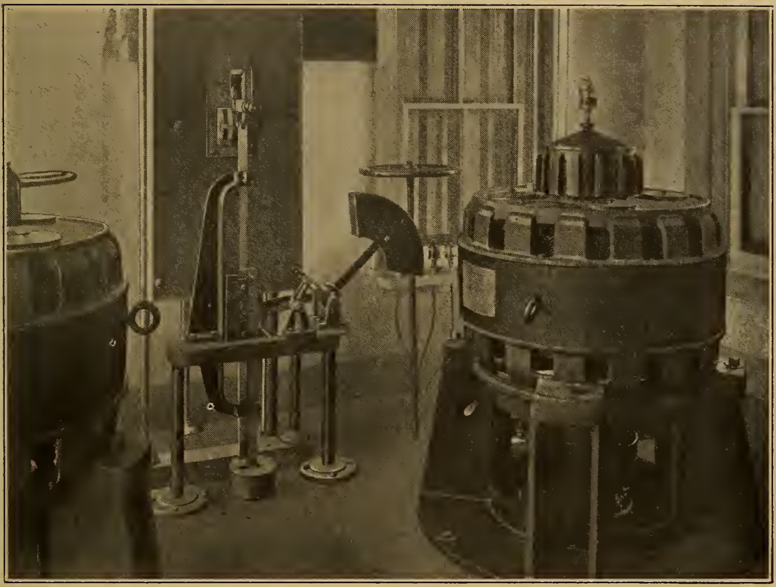
DAYTON SEWAGE PUMPING PLANT. LEHMAN STREET STATION

pneumatic ejectors, which either required too much attention or were too expensive or uncertain in operation, the city of Dayton decided to install automatic electric pumps, and awarded the contracts to the Dayton Hydraulic Machinery Company, builders of the well-known "Brooks" and "Dayton" centrifugal pumps.

When electric motors were decided upon as the driving power, central station power was also accepted as the only satisfactory generating source, since power can be obtained on a moment's notice at any time, night or day. Consequently, there is the entire elimination of steam boiler and engine troubles, as these are all cared for by the central station, which is running at all times, whether the water in the river is high or low. Were any other power adopted for the pumps, the maintenance and operating charges would be increased.

Three stations have, so far, been constructed in various sections of the city. The first is equipped with two vertical 2,500-gallon "Brooks" submerged centrifugal pumps geared to 20 H. P. horizontal, "CCL," three-phase, 60-cycle Westinghouse motors. The motors are started and stopped by standard oil-switched compensators, which are operated by hydraulic pistons controlled by float switches designed and built by the Dayton Hydraulic Machinery Company under their patents. The lift is variable, averaging about 20 feet. The discharge is through a check valve at a point below extreme high water. The operation of these pumps is entirely automatic, it being only necessary to inspect them occasionally and keep the oil receptacles filled. Upon notice of a rise in the river, the gates are closed and the current turned on, after which the pumps cut in and cut out automatically with the rise and fall of the sewage in the pits.

The second station, at Longworth street, has three units, and the third station, at Lehman street, two, each consisting of a double-suction, vertical, submerged 4,500-gallon Brooks centrifugal, direct connected to a 40-horse-power, vertical type, "CCL," three-phase, 60-cycle, 2,080-volt Westinghouse motor.



DAYTON SEWAGE PUMPING PLANT. INTERIOR OF LEHMAN STREET STATION, SHOWING AUTO-STARTER AND TWO 40-H. P. MOTORS

The starting apparatus at these last two stations consists of floats, which operate the valves on a hydraulic piston, using water under pressure from the city mains. On starting, this piston raises the lever on a Westinghouse auto-starter to the starting position, at the same time ro' ting an arm carrying a heavy counterweight, which, by the time the motors have picked up speed, falls, and, by means of a pawl, drops the lever to the running position. On stopping, the reverse motion given the counterweights moved the lift to the cut-out position. The operation of this apparatus is extremely satisfactory, and the motors cut in and cut out automatically with great regularity and smoothness. During a heavy rain, when the river was quite high, one pump was sufficient to take care of the flow in the sewers at the Lehman street station when running three minutes out of each ten, being idle the remaining seven minutes.

### Telescopic Rifle Sight

THE modern prism binocular field glass is well known to travelers, sportsmen and officers, by reason of the combination of high power, large field and extreme portability which it affords. One of the best examples of this instrument is that made by Warner & Swasey, of Cleveland, Ohio.

The same firm has now arranged a modification of the prism telescope as a rifle sight, there being but a single eye-piece and objective, with the corresponding prisms, the whole being arranged for immediate attachment to the rifle. In order to adapt the glass for this purpose, it is fitted with a cam and dial, graduated to indicate the elevation necessary for the trajectory curve corresponding to the distance to be covered.

This improved telescope sight has been under test by the government for several months, and the result has been the placing of a large order by the War Department.

# ANNOUNCEMENTS

The United Gas Machinery Company, incorporated under the laws of the State of New York, have taken offices in the Engineering Building, 114-118 Liberty street, New York City.

They have taken over the business formerly conducted by Thos. F. Fitzsimmons at 100 Broadway, and will manufacture a complete line of gas generators for making producer-gas for gas engines and heating and water-gas for high-temperature furnaces, forges and annealing, etc.

These generators gasify either bituminous or anthracite coal, and are simple, most efficient and economical in their operation. One of their soft-coal gas producers has recently been installed at the S. S. White Dental Company's works at Staten Island.

Thos. F. Fitzsimmons remains with the company as its president and general manager, and his long experience in the application of producer gas to gas engines and water gas to furnaces insure to the purchaser the best possible results.

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The executive offices of the Westinghouse Electric & Manufacturing Company, at 111 Broadway, New York City, and the New York sales offices and export offices of that company, at 11 Pine street, were removed on Monday, April 20, 1908, to the new City Investing Building, No. 165 Broadway, New York.

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The Crocker-Wheeler Company announces the removal of its New York offices from 39 Cortlandt street to the new Hudson Terminal Building, No 32 Cortlandt street, this being known as the Cortlandt Building of the Hudson Terminal, in the basement of which is situated the station of the tunnels extending beneath the Hudson to Jersey City. This is a twenty-two-story building, the largest in New York City, the machinery headquarters of New York. This new location is especially convenient for the business of the company, since it brings the New York office into closer touch than ever with the works and main office at Ampere, N. J.

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Mr. F. P. Thorp, Eastern sales manager of the Power & Mining Machinery Company, announces the removal of the New York offices of the company from 52 William street to No. 115 Broadway. Mr. Thorp represents especially the gas-power department of the Power & Mining Machinery Company, this including the Loomis-Pettibone gas generators and the Snow gas engines.

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Mr. E. E. Keller, for over twenty years connected with the Westinghouse interests and for fourteen years vice-president of the Westinghouse Machine Company, having completed his duties as receiver and general manager, severed his connection with the management of that company on the 1st of April, 1908.

Mr. Keller will take a much-needed rest, and will then devote most of his time to several personal interests.

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The Bristol Company, of Waterbury, Conn., has come under the control of Prof. William H. Bristol, whose inventions this company has been manufacturing since it was first organized in 1889. Prof. Bristol assumed active charge of the management of the business on Friday, March 28, and now owns the majority interest.

The business which has been carried on under the personal name of Wm. H. Bristol at New York will hereafter be combined with the Bristol Company, and by this consolidation of interests the Bristol Company will now have the most complete line of recording instruments in the world for pressure, temperature, elec-

tricity, and for a great variety of other applications.

The Bristol Company was organized in 1889 under the name of "Bristol's Manufacturing Company," to manufacture Bristol's pressure gauges and Bristol's steel belt lacing, for which Wm. H. Bristol had taken out patents. To these were added many other inventions from time to time, and in 1894 the business was incorporated under the name of "The Bristol Company."

Two years ago Wm. H. Bristol withdrew from the presidency of the company, and since that time has developed many new inventions, including the Wm. H. Bristol electric pyrometers and patented smoked chart recorders. The new pyrometers have come into wide use, there being, for instance, fifty of these pyrometers in service in one of the large steel plants.

The new lines of Wm. H. Bristol pyrometers are fitted with special movements made by the Weston Electrical Instrument Company, and are designed for extremely accurate measurements. The combined line of recording instruments to be hereafter manufactured by the Bristol Company will make it possible for the company to co-operate better than ever before with its customers in giving them perfectly satisfactory service.

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The American Locomotive Company desires to announce that, on and after April 24, 1908, the general offices of the company will be situated in the Cortlandt Building, Hudson Terminal, 30 Church street, New York City.

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The Ball & Wood Company has removed its sales office in New York to No. 1422 Cortlandt Building, Hudson Terminal, No. 30 Church street, New York City.

The products of the company include automatic, single-valve steam engines, Corliss valve, non-releasing gear steam engines, high-speed air compressors, welded flanged pipe, bends, etc.

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Mr. B. A. Behrend, chief electrical engineer of the Allis-Chalmers Company, and chief engineer of the Bullock Electric Manufacturing Company, announces that his offices have been removed from Cincinnati to Milwaukee, Wis.

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### Strength of Chain Links

PROFESSOR L. P. BRECKENRIDGE announces that the results of the experiments upon the strength of chain links and circular rings conducted at the experiment station of the University of Illinois have been published in Bulletin No. 18 by C. A. Goodenough and L. E. Moore.

The object of these experiments was to confirm or disprove the theoretical analysis which had been made of the resistance of such links, the investigation being made by a comparison of the calculated and measured distortions.

The result of the experiments is a complete confirmation of the analysis. Having a reliable theory, the bending moments and maximum stresses are calculated for links of various forms, and the results of such calculations are applied to the formulas for the loading of chains given by Unwin, Bach and Weisbach. It is shown that the usual formulas for chain loads give maximum tensile stresses of 33,000 to 40,000 pounds per square inch and maximum compressive stresses of 60,000 pounds per square inch. New formulas for safe loads are proposed. The bulletin is concluded with four appendices, giving in full the theoretical discussion which is the basis of the experimental work.

This bulletin will be of special interest to all engineers and manufacturers who are concerned in any way with hoisting and transmission. Copies may be obtained upon application to the Director, Engineering Experiment Station, Urbana, Ill.

### Quarrying to Dimensions

IN every line of human industry there are both what may be characterized as good work and as bad work. There is also fine work and coarse or rough work; the quarryman may do either as well as the lapidary, and each must have his tools or instruments accordingly. The channeler is among the latest acquisitions of the quarryman, and it enables him to do such work of precision as the ancients never dreamed of.

The methods of the ancient, or at least of the medieval stone-worker, apparently still survive in some countries otherwise to be called civilized. Only last year it was told all through the technical press, as something to be remembered, that a blast of record force and magnitude was set off in Italy to knock away an enormous mass of the finest marble, to be later cut up for statuary and for architectural adornment. We may well believe that such a blast for such a purpose would not have been possible anywhere in the United States. In view of the possibilities and the actual refinements of advanced quarry practice the record blast was something for shame rather than for boasting. Probably few greater contrasts could be found than that of the Italian quarry after the big blast and an American marble quarry in which the chanelling method is fully followed.

None of the raw materials which man gets from the earth are available to him in unlimited quantity, and attention is now being directed all around to the enormous wastes occurring, not in the after-use of the materials so much as in the first act of obtaining them from their natural deposits. Coal, oil and natural gas are specially cited, the complete exhaustion of our attainable supplies of these being distinctly in sight.

Stone might, perhaps, be thoughtlessly looked upon as an exception, the supply of it being certainly inexhaustible; but even stone, with the special qualities which make it desirable for different purposes, is not so common, after all, and the workable beds of it are generally so situated that transportation-costs limit the availability, and no quarry is worked long without the cost of maintainance and of output increasing, so that in any case any quarry owner in his own interest, and without any large views of obligation to the future, should be interested in the husbanding of the material to prolong the life of his quarry.

The channeler not only saves in the large way, but it saves also in every other. It gets out the material in regular shapes and very close to the dimensions required for the blocks, and these can then be finished with a minimum of labour cost and with but slight additional wasting of material. Also when the successive blocks are removed from the bed the surfaces remaining are ready for additional slicing without waste. When a channeler is to begin work at a new quarry the proposition is sufficiently discouraging. Its regular work is usually in rectangular planes, but in the primeval surface there is no suggestion of rectangularity or of any kind of regularity. It can with difficulty find safe standing or traveling room. A quarry which has been operated by the channeling method for a considerable time is as different in appearance and in suggestion as can well be imagined. Here everything has the orderly appearance of an established workshop in which regularly planned and laid-out work can be progressing continually with no delays either for getting ready or for clearing up.

The difference in smoothness of surface and regularity of alignment produced by the channeler from that resulting when drilling and blasting method is employed gives the channeler a special field of its own in cutting the sides of canals and other rock cuttings, some of its work having been done on the sides of the excavation for the New York Terminal of the Pennsylvania.

## Railway Coaling Stations

THE large proportion of the fuel supply of the country which is consumed in the furnaces of steam locomotives renders it desirable that the most effective mechanical appliances should be used for its handling, storage and delivery. A locomotive itself has several different kinds of efficiency; but in all cases it must be remembered that an engine is effective only when it is on the road, hauling traffic and making ton-miles. For this reason every appliance which adds to the number of hours of effective service on the road contributes directly to the commercial efficiency of the machine—the kind of efficiency which appears directly in actual income to the railroad.

Having this kind of efficiency in view, we are led directly to the consideration of such appliances as enable the coaling of locomotive engines to be accomplished with the least loss of time while handling the coal in the most direct manner, and at the same time keeping an accurate record of the quantity and distribution.

Some details of the coal-handling apparatus required for use at railway stations are practically the same as have been found effective in stationary power plants; but modifications must necessarily be made, in view of the difference in operative conditions. Instead of supplying the fuel in a fairly uniform quantity, as to the mechanical stokers of a stationary boiler system, the railway plant must be prepared to supply a number of heavy engines in rapid succession, or await the arrival of others, as the case may be. It is also desirable that the delivery spouts be arranged to serve several tracks, and that all movements be controlled in such a manner as to permit of prompt action upon call.

The essential feature of economy in time involves the provision of power control of chutes in large stations, while for smaller installations hand control is sufficient. By the use of air pressure the amount of labour required for handling may be reduced to a minimum, while the no less important element of time-saving is effected in the same manner, this element in the installation of a station being always subject to the judgment and experience of the designing engineer.

The whole question of the design and installation of a coal-handling plant for a railroad station is a matter which demands skill and experience of a peculiar kind. The railroad engineer understands the operative conditions from his point of view, and it is most essential that these should be met; but he is not always familiar with the methods and appliances which have been devised for the purpose, and in many instances he has had no opportunity of comparing installations elsewhere with the requirements of his own locality.

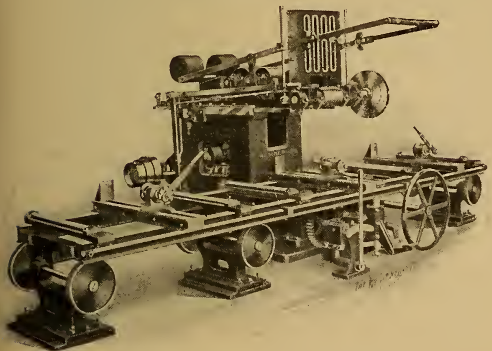
In this respect the design of a railway coaling station resembles that of the same department of a stationary power plant, and in both cases it is the experience and information of the specialist which comes into play in the most effective manner. In the case of the railroad station, as with the stationary plant, the reception of the coal must be considered in the design of the outfit, while in the former instance the requirements of the tracks also come into the problem, and the arrangements for the removal of ashes may well be taken into account at the same time.

An examination of some of the installations of various sizes which have been designed and constructed by specialists for the use of the larger railroads of the country will show the extent to which engineering skill has been applied to this important department of the handling of fuel and ashes, and will indicate the manner in which properly-designed stations add to the efficient operation of the modern railroad.

# Manufacturing News

## A New Automatic Gaining Machine

A NEW improved automatic car gaining machine, specially designed for use in car and bridge construction, or wherever heavy gaining is required, is being made by the J. A. Fay & Egan Company, of 226-246 W. Front street, Cincinnati, Ohio. It is substantially built, and has a capacity for timbers up to 20 inches thick and 24 inches wide. The frame is a heavy cored casting with a broad, substantial base, supporting the working parts without vibration. The gaining arbour and head are supported on a large and powerful automatic ram that is gibbed to the top of the column in planed ways. The ram has a horizontal travel of 26 inches. The arbour frame is gibbed to the front of the ram, and has a vertical adjustment of 21 inches, to suit various thicknesses of stock and depths of gain. To facilitate this adjustment, the arbour frame is counterbalanced. The expansion gaining head is 16 inches in diameter, and will cut gains up to 5 inches deep. The construction of the heads is such that it will make a perfectly clean cut whether feeding forward or backward. The head furnished regularly with the machine will expand to gain from 1½ inches to 3 inches, but special heads may be obtained which will gain up to 9 inches wide. The feed is driven by heavy-cut gears actuated by miter friction. The gears are mounted on shafts running in separate self-oiling bearings. After the outward stroke, the ram returns automatically, or may be stopped at the end of the forward stroke and set to another gain on the return stroke. There are three speeds to the ram drive, viz., 15 inches, 22½ inches and 30 inches per minute. The timber carriage is made of steel I-beams and has automatic friction feed, under constant control of the operator. For accurate adjustments, the carriage is operated by the hand wheel shown in the illustration. The carriage is provided with adjustable stops for regulating the distance between gains, and, as regularly furnished, is 14 feet long, but may be made any desired length. The vertical boring attachment is supported by brackets on the main column, and has an adjustment across the carriage of 18 inches and a stroke of 18 inches.



AN IMPROVED GAINING MACHINE

### The Westinghouse Machine Company's Exports

IT is gratifying to note the continued demand from the Far East for American machinery manufactured at East Pittsburg. Japanese industries are particularly active in this direction, and within a recent period the Westinghouse Machine Company has booked a large number of orders through their Japanese representatives, Messrs. Takata & Co., of New York and Tokio. Outside of turbines and gas engines, the demand for vertical compound steam engines—a characteristic of Westinghouse construction—is as active as ever.

Three 500-KW. Westinghouse turbines have been shipped to the Imperial Steel Works, Japan, and to the Hakkaido Tanko Steamship Company. The Noble School, Japan, has installed a gas engine producer plant. Four 105 horse-power compound engines go to the Taragawa Electric Company, Japan, and to a private isolated plant in China. Other equipments have been ordered by the Acadia Sugar Refining Company and the Yamada Hospital.

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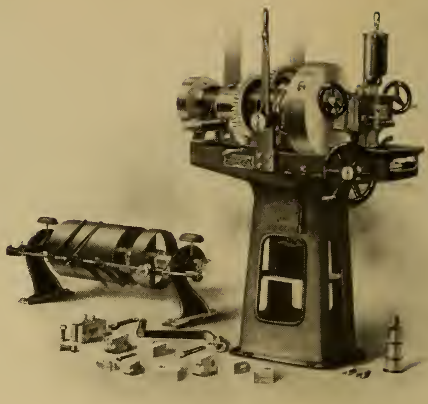
### An Improved Pipe Machine

THE Crane Company, of Chicago, has placed on the market a new pipe machine, called No. 1¼, intended to meet the demand for a low-priced machine, to be operated either by hand or power, for high-class service.

This machine, which is shown in the accompanying illustration, has a capacity of ⅛ to 2 inches, and is designed to withstand any strains produced by cutting or threading pipe between these dimensions. It is arranged so as to provide all the functions of such a machine in the simplest manner, every detail of adjustment and operation having been most carefully studied.

This tool possesses many features which increase output and facilitate ease of operation. The gripping, threading, cutting-off and adjustment



NEW CRANE PIPE MACHINE

have been so arranged that no unnecessary operations are required.

The frame is one casting, having bed and stand in one piece, eliminating the use of light legs and giving greatest rigidity with minimum weight and floor space.

The die head is bolted to a movable carriage, with ample travel. Upon the die head are the dies, pipe guides and cutting-off tool. The dies are of the improved adjustable type, made collapsible, and are similar to those supplied in Crane hand die stocks. The dies are carried in suitable frames, sliding in guides. These frames are moved by a screw operated by a hand wheel. The dies are set to gauge by a simple locking device, which allows any number of pieces of pipe of the same size to be threaded without any further adjustment. These dies have four cutting edges, and will give good service on either steel or wrought-iron pipe. Dies are made interchangeable, and one die of a set may be replaced if broken, thus reducing the repair bill to the minimum. Dies, when not in use on machine, may be used in a hand stock. Change in size of dies may be made in a few seconds.

When cutting off, the pipe is guided by two steel guides, hardened on the face. These guides are operated by a right and left screw and hand wheel. The cutting-off tool is

operated by a lever and rack. This makes a rapid, simple and positive device, and extremely powerful.

The gripping chuck is of the quick-gripping type, rapid in action and very powerful. Pipe may be released and gripped by the throwing of a lever without stopping the machine. The chuck is adjustable to the different sizes of pipe within range of the machine, without moving or altering the jaws. The jaws are of tool steel carried in steel holders, and are removable for grinding or replacing.

The rear end of the spindle contains a universal centering chuck, compact in design and readily adjusted to the various sizes of pipe.

Oil is supplied by a small tank supported on a swivel joint above the die head. A second small tank is placed in the frame, and to this the oil from the dies returns, the supply being controlled by a pet cock.

One pulley is necessary to drive. Three changes of speed are obtained by gears which are shifted by a lever placed on the frame. This device is positive, simple, and cannot get out of order. All machines are supplied with necessary crank for hand operation.

Bolt dies, ¼ to 1½-inch, can be furnished if desired. All necessary pipe gauge blanks, wrenches, etc., are supplied with the machine.

## The American Society of Mechanical Engineers

THE regular meeting of the American Society of Mechanical Engineers will be held in Detroit, Mich., June 23-26. An entire session will be devoted to papers on the conveying of materials, when hoisting and conveying machinery, including belt conveyors, the use of conveying machinery in cement plants, etc., will be discussed.

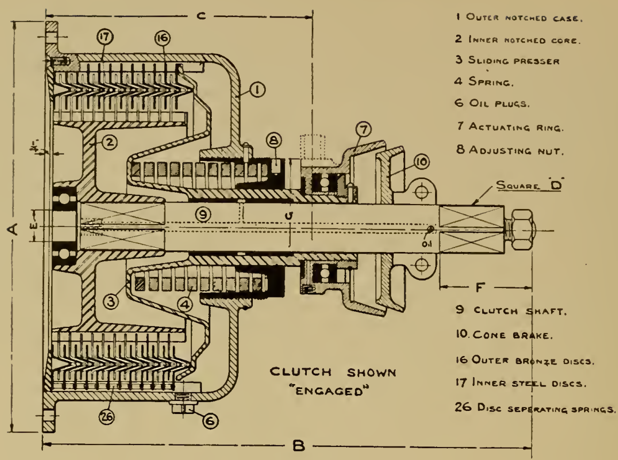
Among other subjects which will be taken up by professional papers are Clutches, with special reference to automobile purchase, by Henry Souther; Some Pitot-Tube Studies by Prof. W. B. Gregory, of Tulane University, New Orleans, La., and Prof. E. W. Schroder, of Cornell University; Thermal Properties of Superheated Steam, by Prof. R. C. H. Hack, of Lehigh University; Horse-Power, Friction Losses and Efficiencies of Gas and Oil Engines, by Prof. Lionel S. Marks, of Harvard University; A Journal Friction Measuring Machine, by Henry Hess, of Philadelphia; A Simple Method of Cleaning Gas Conduits, by W. D. Mount; A Rational Method of Checking Conical Pistons for Stress, by Prof. G. H. Shepard, of Syracuse University, and The By-Product Coke Oven, by W. H. Blauvelt.

A lecture on Contributions of Photography to our Knowledge of Stellar Evolutions will be delivered by Prof. John A. Brashear, of Allegheny, Pa. The usual receptions will be held, and excursions will be made to manufacturing plants, the shipbuilding yards and various points of interest in and around Detroit. Among the excursions planned is one to the University of Michigan, at Ann Arbor. The Gas Power Section of the society will hold a session, and the Society for the Promotion of Engineering Education and the Society of Automobile Engineers will hold a meeting in Detroit at the same time.

## Coke Quenching

CONSIDERABLE interest is being taken in a recent invention (patented by Chas. E. Arnold, of Wilmington, Del.) which relates to a process for quenching coke without the direct use of water, whereby an absolutely dry coke is produced that greatly exceeds in strength coke of ordinary manufacture.

The natural inference is that many coals now unfit for furnace coke will be made available, due to this method of quenching, and that many coal deposits in Illinois, Indiana and elsewhere now considered unfit for coking purposes may be found by this process to produce a satisfactory blast-furnace coke.




THE HELE-SHAW FRICTION CLUTCH

## An Improved Friction Clutch

MERCHANT & EVANS CO., of Philadelphia, report a continually increasing interest in their manufacturing and engineering department. It has been necessary for them to secure additional shop room and greatly extend their machine tool facilities. They now have one of the most completely equipped modern machine tool shops in the country for work of precision, with a complement of such tools as Gisholt, Jones & Lamson, Lodge & Shipley, American and Pratt & Whitney lathes, Becker, Bullock and Lucas boring mills, Dreses and Light drills, Becker-Brainerd and Kempsmith millers, Gould & Eberhardt shapers; slotters, broachers and a complete variety of small tools of every description.

With this equipment they can make quick delivery of their growing orders in this department and produce their output at the minimum of shop cost and the maximum of excellence according to the best American practice.

They are now contracting for an expensive double-action heavy press equipment for the manufacture of large and deep steel stampings of every sort.

One of the noticeable specialties of this company is the "Hele-Shaw" clutch, which has secured its greatest popularity for use in automobile construction, but which has been very extensively and successfully employed in a wide range of mechanical drives of every description abroad.

The English manufacturers, from whom Merchant & Evans Co. have secured the exclusive license under the American patents for the manufacture of this clutch, have installed something like 25,000 horse-power in the past four years in England and Europe and foreign countries in over fifty different applications, ranging from 1 to 1,000 horse-power.

A brief description of this device, which has remarkable qualities of efficiency, smoothness of action and endurance combined, with great compactness and comparatively small size—thus making it peculiarly suited for very heavy duty in very small space—will doubtless interest our readers.

The peculiarity of the clutch and also the merit lie in the fact that the engagement of the plates, instead of being flat, as heretofore, is in a 35-degree, V-shaped circumferential groove. Although a trifling mechanical change to the casual thinker, it constitutes the whole difference between success and failure in a metallic disc clutch. First by virtue of engaging a V-groove of one-third of a

plane surface, each pair of plates does three times the work of any flat pair, or the same work with one-third the spring pressure. It is obvious, therefore, that at the same engaging spring pressure the Hele-Shaw clutch will do three times the work of any other metallic disc clutch of a similar design, or in a restricted space that the Hele-Shaw clutch one-third the size of any similar clutch will do this work equally well.

By virtue of the engagement in a V-shaped groove the flat portions of the plates, or the fins, as they are called, are always separated by about ⅛ inch. This permits the circulation of an oil bath constantly right up to the point of work and radiates heat continuously, thus preventing the Hele-Shaw clutch from ever heating, due to slippage, whereas flat plates, in engaging, constitute a solid pack of metal normally, and will so heat as to carbonize or blacken the oil. In the event of the accidental absence of oil the same amount of heat that would distort a flat plate does no injury to the Hele-Shaw plate, because of its transverse rigidity, due to its peculiar groove. It, therefore, cannot be injured by heat. This makes it peculiarly advantageous for constant-dutv work, such as planer and machine tool reverse gears, automobile and motor-boat work, all automobile drives, where the clutch is constantly working in and out of engagement, pulley and coupling work at important points, cranes, gas engine and electric motor drives, rope-drive work for conveyors, hoists, etc.

The range of successful application which has already been discovered and completely proven in practice for the Hele-Shaw clutch in the industrial arts is too long to be enumerated in detail.

A peculiarity of this clutch, which puts it in a class apart from any other one, is its uniform rate of pick-up. When thrown into engagement it picks up its load on a straight, diagrammatic line instead of a curved one. This peculiarly gratifying property of the Hele-Shaw clutch appeared in its experimental try-outs, and was later proven in practice by its employment to couple up alternating (constant speed) electric motors to Hoe printing presses. Unless the rate of pickup in this engagement is absolutely uniform from a state of rest to full speed, the damp paper in the press is torn. A number of large electrically-driven printing establishments in London are now coupled by Hele-Shaw clutches with perfect operating results in practice. This excellent property of the clutch makes it peculiarly desirable for dynamometer work and refined drives of every character.

Each driving problem requires its peculiar engineering solution. Merchant & Evans Co. will be very glad to make a study of any clutch need for any work, and give full information about the application of the Hele-Shaw clutch, with prices.

In addition to this wide range of specialized engineering work, Merchant & Evans Co. are putting out a complete line of automobile parts for industrial and pleasure cars, such as rear axles and transmissions, front axles, four-cylinder motors, with or without clutch, for motor-boat as well as car use, and the "Star" stamped metal tire case.

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### The Nash Gas Engine

The National Meter Company has just issued a handsome booklet devoted to the Nash engine, both as intended to be operated from a gas supply of any independent source, and as arranged with the gas producer or for liquid fuel.

These engines have been designed to meet the requirements of absolute reliability, close regulation, and the greatest possible economy, and are shown applied to electric machinery, blowing, pumping, and general power development.

The Nash gas engine is built in sizes from 5 to 250-H. P. units, and is applicable to all kinds of service.

### Announcements

The A. P. Gerald Company announce that it has entered the field of steam-boiler work, with especial reference to the erection, dismantling and re-erecting of boilers of all kinds, as well as the cleaning and repairing of steam generators. The company includes Messrs. A. P. Gerald, William Lloyd and M. Wright, all men of long, practical experience in the field of water-tube boilers of various kinds, and there should be ample opportunity for its services to be utilized by manufacturers and steam users generally.

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The Goldschmidt Thermit Company announces the establishment of a branch office and works at 103 Richmond street, West, Toronto, Canada. The new branch was opened for business May 1, and is under the management of Mr. E. C. Rutherford, of Toronto. Mr. Rutherford is a Canadian by birth, and has a wide acquaintance among the business men of the Dominion, having been for several years manager of the Hagann Air Brake Company, and also of the Canadian Brake & Supply Company. A complete stock of thermit and appliances will at all times be carried at Toronto, and the branch organization will be in a position to execute promptly the welding of heavy steel sections, such as stern posts of steamships, crankshafts, etc., as well as trolley rails in paved streets, electric motor cases and other broken steel sections. A fully equipped repair shop will be in operation for the repair of steel castings up to 1,000 pounds in weight.

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Dr. Schuyler Skaats Wheeler, past president of the American Institute of Electrical Engineers and president of Crocker-Wheeler Company, recently (May 4) addressed the Engineering Society of Columbia University on the subject of Engineering Honour. As an undergraduate at Columbia, in the class of '83, he, with Prof. F. B. Crocker, had addressed the same society on technical subjects.

After declaring that he felt the audience before him to be more sympathetic than any of the audiences he had addressed on engineering ethics, he alluded to the ethical codes of the various so-called learned professions. He spoke also of the code which he proposed in his presidential address before the American Institute of Electrical Engineers.

Dr. Wheeler mentioned the three great duties of the engineer in the order of their importance; first, the engineer's duty to his client; second, to the public; and third, to his engineering society. He condemned strongly the publication of false scientific and false engineering statements in the newspapers, and he declared that discoveries and inventions should be announced not in the daily papers, but through the technical societies or the technical press.

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### Graphite in Gas Engines

THE manager of the gas engine department of a well-known engine manufacturing company reports that he is very much interested in graphite for the cylinders of gas engines. They have been using the regular No. 1 Flake Dixon Graphite with excellent results, and are extending their experiments more and more. Further experiments will make use of the finely pulverized flake graphite, Dixon's No. 635.

The experiments have demonstrated that, where Dixon's regular No. 1 Flake Graphite is used, there has been no trouble with fouling of the igniter or with pre-ignition.

The manner of feeding the graphite is through a small opening near the highest point in the air intake pipe. The feeding of graphite, however, in this manner necessitates dependence upon the memory of some man; therefore, the best results and uniform results cannot be obtained as readily as when the graphite is fed by some automatic or mechanical lubricator.

# THE LATEST CATALOGUES

**Roads**

Barrett Manufacturing Company, New York.—Descriptive pamphlet treating of the prevention of the formation of dust upon macadam roads by the use of Tarvia, a composition which acts as a binder when applied to a road surface. Numerous illustrations are given of roads in cities, parks, cemeteries and suburbs, showing the effectiveness of the treatment, and the advantages of the system are clearly set forth. The prevention of dust is one of the important problems necessarily arising out of the development of mechanically-propelled vehicles, and it is evident that some such improvement in the surfacing of highways as is effected by the use of Tarvia must come into extensive use.

**Boilers**

Coatesville Boiler Works, Coatesville, Pa.—Illustrated pamphlet devoted to the products of the establishment in plate-metal construction, including return tubular boilers, internally-fired boilers, steel stacks, cooling towers, stand pipes, etc. Useful tables relating to boilers, tanks, stacks, etc., are included.

**Conveyors**

Jeffrey Manufacturing Company, Columbus, Ohio.—Catalogue of Jeffrey rubber-belt conveying machinery, with numerous illustrations showing the application of belt-conveyors to the handling of materials of all kinds. The conveyors are shown in service in various parts of the world, and for a great variety of materials, together with accessories, such as belt trippers, pulley carriers, guide pulleys, etc.

**Coal Handling**

Dodge Coal Storage Company, Philadelphia, Pa.—Book No. 70, treating of the subject of the handling of coal and ore by the Dodge system, employing a chain conveyor, supported by a steel truss, piling the coal mechanically into symmetrical heaps, and provided with a reloading machine for subsequent delivery. Illustrations of a number of large installations are shown, as well as applications of the system to indoor service.

**Asphalt**

The Watson-Stillman Company, New York.—Pamphlet describing the Lewis-Gammie asphalt cutter, a portable machine fitted with revolving cutters for the removal of a strip of asphalt pavement to permit the excavation of the ground beneath. The rotary cutters enable a straight, clean cut to be made, the asphalt being removed in slabs suitable for replacement after the work is completed, the power being supplied by a gasoline engine forming a part of the equipment. This apparatus is especially adapted for the work of water, gas and electric companies for pipe-laying or conduit work, as well as to contractors or municipalities for making repairs.

**Boiler Tools**

A. L. Henderer's Sons, Wilmington, Del.—Bound collection of leaflets describing boilermakers' specialties, such as roller tube expanders, screw and hydraulic punches, clamps, hydraulic jacks, shears, etc.

**Hydraulic Machinery**

The Waterbury Farrel Foundry & Machine Company, Waterbury, Conn.—Catalogue, Section H, being a fully illustrated catalogue of hydraulic presses for all kinds of service, pipe testers, drawing presses, push benches, accumulators and hydraulic pressure pumps. A variety of valves for use with hydraulic machinery are also shown, the whole forming a very complete list of machines for the production and utilization of hydraulic pressure.

**Regulation of Electric Motors**

WITH the general introduction of electric motors for all kinds of service there has been developed a variety of devices for their control and regulation. These devices, including switches, fuses, starters, etc., have been improved from time to time, and in the earlier installations, or in such large plants as include a general and complete electric equipment, they have been placed as seemed most convenient.

In many places, however, an electric motor is installed where it is desirable to have it complete in itself, and this demand has grown so extensive that it has led to the manufacture of a complete line of starting panels, these containing in one set every necessary device for the complete installation of an electric motor.

The extent of the demand for such panels, known commercially as Universal Motor Starters, is seen by the fact that one manufacturer has a line of starters ranging in capacity from ¼ to 35 horse-power for 110 volts, and from ¼ to 50 horse-power for 220 and 500 volts.

The design of such devices involves a familiarity not only with the principles of electrical engineering, but with the practical requirements which have grown up with experience. Thus the present rule of the underwriters requires that no live parts shall be carried on the back of the panel, so that all connections must be made on the front. For small sizes button-contacts are found satisfactory; but for larger connections it has been found advisable to provide segments which offer a larger area and which may be attached to the slate panel by two screws. Such panels include also an arrangement of magnet coils which protect the motor from overloads or failure of voltage by bringing the starting lever back to the all resistance in circuit position in case of abnormal fluctuations of the line voltage. It is thus possible to install the entire apparatus for the control and regulation of an electric motor in a single piece of apparatus, including starting box, with no-voltage and overhead release knife switch and fuses, greatly simplifying the introduction of electric power for all purposes.

UNIVERSAL MOTOR STARTERS. THE CUTLER-HAMMER CO., MILWAUKEE, WIS.

### Efficiency in Power Plants

THERE are many kinds of efficiencies to be considered in making up the total efficiency of a manufacturing establishment, certain of the elements involved being common to nearly all kinds of work, while others naturally vary with the character of the business. At the present time the tendency toward centralization renders the establishments devoted to the manufacture of power of especial interest to the engineer, since it is in such plants that the latest developments of engineering skill and manufacture are gathered, with the object of the attainment of the highest degree of efficiency in the conduct of a commercial business based upon the conversion of fuel into power.

The present interest in the conservation of the fuel supply of the nation naturally causes especial attention to be given to the actual processes of the combustion of coal and the generation of steam, since it is in the great power plants of the country that the highest economies may be expected to appear. Apart from the actual value of the coal consumed, however, the power-plant engineer has to consider the other important element in the cost of power—the expenses involved in the labour and handling details of the problem. As a matter of fact, the operative costs of a power plant may be considered as about equally divided between the two main elements of fuel and labour, and each demands equal attention, both in original equipment and in daily operation.

With the increasing cost of labour a large part of the effort of the engineer has been devoted to the design and installation of mechanism which shall take the place of manual labour, rightly judging that it is far more desirable for the labour to be limited to a minimum number of highly skilled men controlling inanimate mechanism than to be dependent upon a greater number of men of a lower grade. The result of this effort has been the introduction of numerous appliances well known as adding greatly to the efficiency of the modern power plant. Thus both boilers and engines of far greater capacity than formerly are in use, the larger units requiring little or no greater labour for their operation than the smaller units formerly in use, since the actual effort is effected mechanically, the part of the attendant being limited to control and direction.

This line of improvement naturally extends to the handling of the fuel, both with respect to the delivery of the coal and the removal of the ashes, and the whole subject of coal and ash-handling now forms an important department of design and manufacture in the equipment of the modern power plant.

Apart from the improved efficiency which is effected by the substitution of machinery for manual labour in the handling of fuel, there appears another element which may conduce in a marked degree to the commercial efficiency of a plant, the ultimate test by which its continued existence must be justified. This is the possibility of the use of locations otherwise not practicable, enabling sites to be chosen for commercial reasons, often with the saving of important fixed charges, or with possibilities in the reduction of other costs. Thus, the situation of a power plant may be determined by the relative cost of the land, by the advantages in the distribution of the power, by questions altogether of a commercial character; and then the engineer is called in to provide means for getting the fuel in and the ashes out, in a manner which, had manual labour been required, would have been a serious and costly burden. Doubtless it is most desirable to select sites with due consideration to the question of fuel supply, and there is every reason to appreciate this element at its full value; but it is no longer a controlling one, and this because of the development of efficient mechanical appliances for the handling of the material.

# Manufacturing News

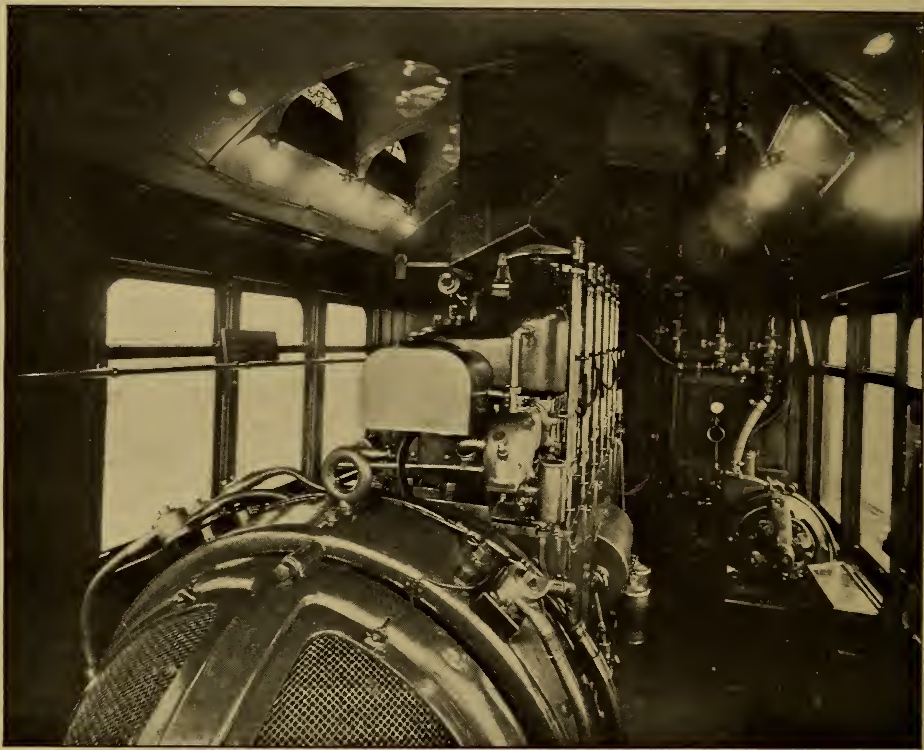
## The Strang Gas-Electric Car

DURING the period of transformation which must necessarily precede the introduction of electric power upon various railways now operated by steam locomotives the plan of constructing motor cars containing their own source of power, and yet having the flexibility and control of the electric system, has been seriously considered. One of the most interesting developments of this idea is seen in the Strang car, combining in one machine the advantages of the internal-combustion motor as a prime mover and the adaptability of electricity in the transmission of the power from the engine to the driving wheels.

We illustrate herewith the Strang car "Irene," recently built by the J. G. Brill Company for the Strang Gas-Electric Car Company, showing the manner in which the system is adapted for the equipment of branch and feeder portions of the larger steam railway systems.


MOTOR CAR IRENE, STRANG SYSTEM. BUILT FOR THE STRANG GAS-ELECTRIC CAR COMPANY BY THE J. G. BRILL COMPANY

The Strang system consists of a gas engine with a direct-connected generator, electric transmitter and control, direct electrical connection between the generator and truck motors and a storage battery. The operation of the car is practically the same as an interurban trolley car; but, unlike the trolley car, it produces its own current, and is, therefore, independent of trolley wire and



THE STRANG GAS-ELECTRIC CAR. INTERIOR OF FOWER COMPARTMENT

power house; in fact, it carries a complete power house with it. The generator and engine have a capacity sufficient for normal requirements, the generator furnishing all the current necessary; but when starting or when ascending a grade the current necessary would demand an engine and generator of much larger capacity were it not for the storage battery. The storage battery, therefore, takes care of what is called the "peak" of the load, or that which is in excess of normal requirements. The storage battery is charged while the car is coasting down grades, coming to a stop or standing still, the engine running until automatically throttled, when the batteries attain the full capacity.

The system of control is the same as in use in the New York subway and elevated roads, and is called the "multiple-unit control," which enables the car to furnish current to other cars equipped with motors to which it may be coupled. The engine, generators, motors and practically all the machinery was designed and manufactured by the Strang Gas-Electric Car Company, and many of the devices which control the machinery have been especially devised and are important improvements over anything of the kind accomplished before, such as automatic control of engines by the condition of the battery, roof arrangement for water system of heat radiation, high-tension ignition system, etc. The car carries sufficient gasoline to carry it 200 miles, and consumes about six-tenths of a gallon per mile. The engine cooling system consists of radiators placed on the roof of the car and a circulation secured by a motor-driven turbine pump. The passenger compartments are heated by pipes connected with the water system.

The "Irene" measures 66 feet in

length over all; weight complete, 114,000 pounds. The engine is of vertical, four-cylinder type, having six cylinders, 10½ inches by 9 inches; 150 horse-power, at 435 revolutions per minute (continuous rating); generator of 85 KW., 250 volts. d. c., shunt-wound interpole; battery of 112 cells; Plante type of 300 ampere-hours capacity; type "M" control; automatic air brakes. The cooling and heating system consists of an electrically-driven centrifugal pump, circulating jacket water through radiators on roof or through heating pipes in passenger compartment. Trucks of standard Brill No. 27-E3 type. The car body was designed by W. B. Strang, president, and L. G. Nilson, chief engineer, of the Strang Gas-Electric Car Company. The engine and accessories were designed by Mr. L. G. Nilson, and the generator and motors were designed and built at the company's shops under the personal supervision of Messrs. Strang and Nilson.

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### American Bridge to Cross River Nile at Cairo, Egypt

CABLE advices from Cairo, Egypt, state that the contract for the construction of a new bridge to cross the Nile River at Cairo, which will cost more than $1,500,000, has been let by the Ministry of Public Works of the Egyptian Government to the Compagnie de Fives-Lille of France, after an international competition in bidding for its construction. The new bridge, which will be located at the deepest part of the Nile River, and will lead directly to the site where the Boulac Museum stood, is to be built in accordance with plans prepared by the late Sir Benjamin Baker, of London, the engineer of the great Forth Bridge, Scotland, and the Scherzer Rolling Lift Bridge Company, of Chicago, the latter company also furnishing consulting engineering services during erection. The entire work is to be executed under the charge of the Ministry of Public Works of the Egyptian Government, and it is expected that the new bridge will be completed and in service before the end of the year 1910.

This large, modern bridge will be in striking contrast to some of the old types of slow-moving bridges across the Nile. It has a total length between abutments of 274.5 meters. The total width of the bridge will be 18 meters, divided into two footpaths of 3 meters each; a tramway track of 5 meters, to carry double lines of electric tramway of 1 meter gauge, and 7 meters of road clearance. The structure will consist of a Scherzer rolling lift bridge with four fixed approach spans. On the Boulac side of the Nile quay walls will be constructed on masonry wells. The south end of the abutment on this side of the river will join the existing quay wall, and the north end will ultimately be joined to the quays under construction. The piers and abutments, which will be of Assouan granite, are to be built on foundations to be sunk by compressed air. The Scherzer rolling lift bridge will have a movable span of 30 meters, to allow the passage of boats.

In order to facilitate the heavy water and land traffic at this site, which is in the most prominent part of the Egyptian metropolis, the Scherzer rolling lift bridge is designed to operate very rapidly, the time required to open or close the bridge being less than thirty seconds. This result is accomplished by the use of the most modern electric equipment.

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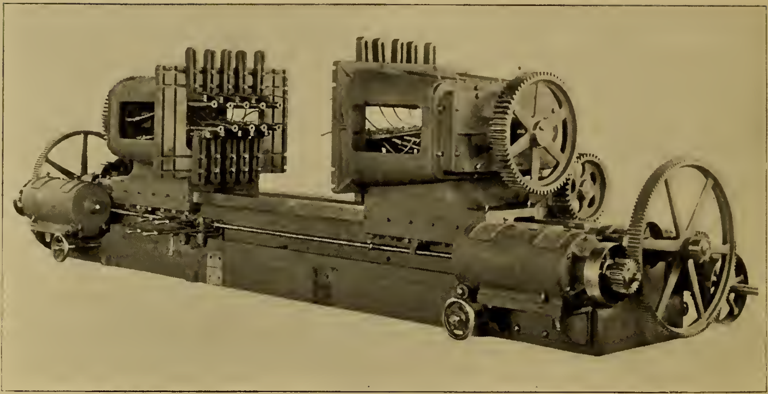
We have received from the George N. Pierce Company, of Buffalo, a handsome publication entitled "The Factory Behind the Great Arrow Car," the text being written by Mr. John Foord, and both text and illustrations giving a full account of the new works at which the "Great Arrow" automobile is built. An extended review of this effective book will be given hereafter.



SPECIAL HORIZONTAL MULTIPLE DRILLING MACHINE. BAUSH MACHINE TOOL COMPANY, SPRINGFIELD, MASS.

### An Important Machine Tool

THE specialization of various departments of work calls for special tools to enable modern shop methods to be conducted with the efficiency demanded by present systems of works management. Thus, the so-called Bethlehem sections in structural steel, manufactured by the Bethlehem Steel Company under the Grey process, have called forth some excellent machines for drilling the various parts, and we illustrate one of a number of tools designed and built for the purpose by the Baush Machine Tool Company, of Springfield, Mass.

The equipment for this one plant consists of eight double-head horizontal and four single-head vertical machines, arranged in a line, with every other machine on a sliding base, to accommodate the drilling of various lengths, as may be required.

The double-head horizontal machines shown in the illustration are made in two sizes, one size carrying 12-inch by 48-inch heads; that is, the adjustable drill spindles cover any layout within a 12-inch by 48-inch rectangle. These heads are equipped with eighteen drill spindles each. The other size carries heads 12 inches by 24 inches, with ten spindles to each head. Both heads on the horizontal machine are operated independently or together, at the will of the operator.

The single-head vertical machines are also built in two sizes, one carrying sixteen drill spindles on a working rectangle of 12 inches by 36 inches, and the other carrying ten drill spindles on a working rectangle of 12 inches by 24 inches.

All spindles have No. 3 Morse taper, and are designed for drilling 1-inch holes in soft steel at a speed of 55 feet per minute on the periphery of the drill, with a range of feed up to .01 of an inch per revolution of the spindle.

Each head is equipped with an oil pump, pan, reservoir and connections to each spindle, to allow of oiling each drill independently; also with a two-speed quick return of the drills.

The double-head horizontal machines are for drilling flanges and the vertical are for drilling the web. This allows the necessary drilling with the minimum handling of the work. In the case of the double-head horizontal machines each head sustains the drilling pressure of its opposite. In both style of machines each head is independently driven by a variable-speed motor, and, in case of the movable machines, an extra motor is required for that purpose. The eighteen spindle heads are driven by 25 horse-power motors, the six-

teen spindle heads by 20 horse-power motors, and the ten spindle heads by 15 horse-power motors.

The vertical machines weigh about 11,000 pounds and the double-head horizontals about 25,000 pounds, without motors.

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## New Use of Manganese Steel

A GOOD example of how the development of one industry helps another is found in an order for manganese steel discs recently placed by the Cutler-Hammer Clutch Company, of Milwaukee. This company, in addition to manufacturing magnetic clutches, makes a specialty of lifting magnets for handling pig-iron and scrap metal. The growth of this latter business, and the natural desire of the manufacturers to perfect every detail of their product, have led to the adoption of manganese steel for coil shields, the coil shield being the flat disk fastened to the under side of the lifting magnet for the double purpose of protecting the magnetizing coil and interposing between the two poles of the magnet an area of non-magnetic material. Brass, which is non-magnetic, has heretofore been used for this purpose. Ordinary steel will not do, because it is a magnetic metal, and would serve to conduct the magnetic lines of force from pole to pole instead of compelling them to seek a passage through the material to be lifted. Manganese steel seems to be the ideal metal for this purpose. It is non-magnetic, like brass, and infinitely harder—so hard, in fact, that the continued hammering of the pig-iron or other metal on the under surface of the magnet makes not the slightest impression on it. The 50-inch magnets recently furnished by the Cutler-Hammer Clutch Company to a number of steel mills in the Pittsburg district are all equipped with manganese steel coil shields instead of with the brass coil shields formerly used.

## Electric Locomotives for Mines

THE first electric mine locomotive was built in 1887. At that time it was a startling innovation, and general doubt as to its usefulness was expressed. In appearance it was very unlike the one of to-day. Among other things, its height was too great for the low gangways found in many mines. It looks as clumsy, compared to its modern successor, as the model of the first railway locomotive beside the gigantic machines turned out from the shop in the year 1907.

Some of these early creations, however, have lasted straight through the period of improvement, and are still in operation. One such was built in 1889. At the time of the Pan-American Exposition, in Buffalo, the officials whose duty it was to gather exhibits for the Electrical Building decided to obtain this locomotive. They wrote to the manager of the mine where it had been used to ask if it could be "resurrected from the scrap heap." The manager replied, with some indignation, that it could not be "resurrected from the scrap heap," being still in operation; but that it could be loaned, provided a new locomotive were to be substituted to do the work during its absence.

In the early nineties came the "terrapin back," more nearly approaching the squat machine now in general use. Like the type that preceded, it was equipped with one motor, and the axles were coupled together by connecting-rods. Then came the locomotive with two motors, the axles being driven independently. In general character this is the locomotive of the present day.

Without abandoning any of the already established methods of transportation, the anthracite mining companies have made great outlays upon the installation of electricity within the last decade. The use of the new force brought with it the employment of a new class of skilled labour and the necessity of improving the tracks

to bear heavier loads. The mobilization of longer trains of mine cars than the mules could haul has tended to greater complexity of operation.

"In our mines," one general manager said recently, "the hauls—some of them at least—are getting entirely too long for mules. I know of one haul that is as long as three miles: it is three miles, that is, from the 'breast' where the coal is mined through the gangways to the shaft. It is getting simply impossible to manage such a proposition as that with mules. We have tried compressed air, but now we've decided that electricity is the best. It is not likely that this company will ever buy another air locomotive. We are adding to our supply of electric locomotives every year."

Electricity demands a much firmer and stronger track than does the mule. Manufacturers of electric locomotives invariably urge the adoption of heavier rails. "For animal and rope hauling," says one, "the prevailing light rails are satisfactory; but for the locomotive of traction haulage the rails should be much heavier—in fact, the heavier the better." With the miles of track that have to be laid this means great expense. For a 10-ton locomotive a rail weighing 25 pounds to the yard is prescribed as a minimum, but a 45-pound rail is recommended.

Electric traction introduces new engineering tasks in the matter of grades. With the mules there does not have to be any such fixed, mathematical rule governing the grade, for the number of mules can be increased at certain places, according to requirements. But the capabilities of a locomotive are the same at all times, and grades have to be reduced accordingly. It is the adverse grades that determine the size of a locomotive in any particular mine. Though they can climb a 12 per cent. or even a 15 per cent. grade, with heavy rails, the locomotive cannot be called upon to perform economically on long runs against grades of more than 3 per cent. Consequently, there has had to be a great deal of work towards leveling the gangways.

When mechanical power supplants mules, the bonding of the rails becomes at once an important factor in mine transportation. The bonds must be carefully inspected, and, when they are loose, tightened or replaced. At the sharp curves in the mines provision has to be made for the increased track resistance. The outer rail has to be elevated as on regular railroads on the surface.

In a mine gangway the location of the trolley wire is not as simple a matter as it is on the streets and on country roads, for space is very limited. The wire must be installed in such a manner that it will cause the least possible interference with free passage of men and animals. The character of the overhead work has an important bearing upon the successful operation of the locomotive. A man of thorough experience has to supervise the installation.

A mine-haulage system has to have a regular schedule, just like a street railway or a subway. If one locomotive is going from the shaft with a train of "empties" while another goes toward it with a loaded train, it means a saving in the size of generator and engine. Keeping such schedules involves employing well-paid men, who are capable of running things smoothly and avoiding the confusion which means loss of time and loss of money.

One needs only to make a visit to the mines to see how the whole aspect of mining has been changed by the introduction of electricity. It is not merely the purchase of the locomotive and trolley wires, but the creation of numerous correlative expenses that makes of mechanical traction a problem to trouble the mine manager. It is a form of expenditure which does not bring in any direct income, but which has to be incurred. It is made a necessity because of the exhaustion of the easily accessible veins of coal.

### "Asphalt" and "Pitch"

ANYONE who has had frequent occasion to read specifications for roofing or waterproofing has probably noticed the indefinite way in which the terms "asphalt" and "pitch" are often used. Sometimes they are assumed to mean one and the same thing, sometimes they are regarded as alternates, and sometimes asphalt will be mentioned where the context and general practice clearly indicate that coal-tar pitch is meant. And this is found not only in specifications for unimportant work prepared by men of limited experience, but occurs in the case of engineers, architects and contractors of wide reputation, engaged on large and costly undertakings. Indeed, among those who have not given this detail careful attention the word "asphalt" seems often to carry a sort of glamour that results in its use where any material of this character is to be specified.

As a matter of fact, the general term is pitch, and it includes all substances of that nature from whatever source, the dictionary definition of asphalt being "mineral pitch." Therefore, while all asphalt may be called pitch, all pitch cannot be termed asphalt. Of the kinds of asphalt pitch, or more briefly, asphalt, that can be used for waterproofing, there are barely four or five out of fifty or more varieties that are in any respect suitable for such purposes. Of the other kinds of pitch there is only one—coal-tar pitch—that can be considered for such work.

As between the two, engineers who have taken the time to investigate their relative waterproofing qualities are practically of one opinion, that coal-tar pitch is at least as good as any asphalt. Evidence as to the correctness of this statement is being constantly furnished from old buildings where coal-tar pitch has been in use twenty and thirty years and yet is chemically, mechanically and in every other respect in exactly the same condition as when first applied.

When asphalt is specified in the lax manner above described the chances are much in favour of coal-tar pitch being used, as few inspectors are capable of distinguishing between the two, and coal-tar pitch is from 25 to 50 per cent. cheaper. Bidders who estimate in good faith on the use of asphalt find their figures too high for consideration, and, to get the work, must either get the specifications relaxed or, if less scrupulous, use coal-tar pitch, anyway—a practice that cannot well be defended.

In either case injustice is done to the reputation of coal-tar pitch, as it must bear the reproach of being "something just as good," or else travel under a false name and miss the credit of its own good performance. It would be far better from both an ethical and an engineering point of view if accurate terms of specification were arrived at in the first place, and used with a proper understanding of their meaning. If asphalt is required, it should be specified by brand or place of origin, and if coal-tar pitch is desired, it should be plainly specified as such.

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### The Gas Engine Industry

IT is a matter worthy of interested attention that the manufacture of the gas engine, from becoming a sort of minor, specialized industry, has, during the past few years, grown into an important department of a number of the great manufacturing establishments. This is a natural consequence of the demand for engines of a large size, equalling in power that of large steam engines, and demanding even great engineering skill and more complete shop equipment for their construction. The gas engine industry, as well as the manufacture of small engines for automobiles, has also had its influence upon the development of certain classes of machine tools, an influence which is likely to be both deep and far-reaching in its effects.

### Announcements

The Dean of Columbia University announces the appointment of Mr. Arthur Julian Walker as professor of metallurgy and administrative head of the Department of Metallurgy in the university. Professor Walker has had an extensive practical experience with the Old Dominion Copper Company, Silver King Mining Company, Baltimore Copper Company, Guggenheim Smelting Company and American Smelting & Refining Company. He will take personal direction of the instruction in non-ferrous and electro-metallurgy and in metallurgical design. Dr. H. M. Howe will continue to deliver his lectures on iron and steel.

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The faculty of the Massachusetts Institute of Technology has just conferred the degree of Master of Science on three graduate students in the electrical engineering course—Mr. R. B. Anthony, who graduated from the University of Wisconsin; Mr. E. L. Moreland, who graduated from the Johns Hopkins University, and Mr. F. W. Willey, who graduated from Purdue University. Thirty-eight students—ten of whom are already graduates of liberal arts courses and three are graduates of the mechanical engineering course of the institute—have been granted the degree of Bachelor of Science in the electrical engineering course.

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It is announced by the Bethlehem Steel Company that, in addition to its present line of heavy general machinery, it has entered the field of the manufacture of power-generating machinery, including internal-combustion engines. The power department has been placed in the hands of Mr. Arthur West, whose experience in this line of work, both with the Allis-Chalmers Company and with the Westinghouse Machine Company, renders him especially well equipped to build up the power plant department thus undertaken by the Bethlehem Steel Company.

The Abendroth & Root Manufacturing Company announce the removal of their New York sales offices to the Fulton Building of the Hudson Terminal, No. 50 Church street, New York City. The works of the company, devoted to the manufacture of Root spiral-riveted pipe and the Root sectional water-tube boilers, as well as to machine and foundry work and boiler and plate construction work, are at Newburgh, N. Y.

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The American Electric Lamp Company of New York, whose New York office was located at 26 Cortlandt street, has arranged with the Central Electrical Supply Company, 29 West Fifteenth street, to become their sole selling agents in Greater New York.

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Beginning with the July issue, the "Engineer and Fireman," published by the Penberthy Injector Company, of Detroit, Mich., will be increased from 32 pages to an 80-page magazine, with 10,000 monthly circulation, and full of interesting and instructive reading matter of a mechanical nature. Free sample copy will be mailed to any reader of CASSIER'S MAGAZINE, upon request.

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It is with deep regret that we note the death of Mr. B. H. Thwaite, well known in the engineering profession on both sides of the Atlantic, and especially in connection with the development of gas power from the waste gases of metallurgical furnaces. Mr. Thwaite was the senior partner of the firm of Thwaite & Thorpe, of London, and had devoted much of his professional career to the metallurgy of iron and steel and to the economical development of power. An excellent portrait of Mr. Thwaite appeared in the issue of this magazine for November, 1907, in which issue he also contributed a paper upon the blast furnace, considered as a centre of power production.

# THE LATEST CATALOGUES

### Dredge

WETHERILL BROS. MACHINE COMPANY, Chester, Pa.—Large pamphlet, illustrating and describing the 10-inch hydraulic dredge *Dalecarlia,* built for the United States Government for use in cleaning out the Dalecarlia reservoir near Washington, D. C. Several photographs of the dredge and its machinery are shown, together with the specification of the outfit and some account of the work it is accomplishing.

### Conveying

DODGE COAL STORAGE COMPANY, Philadelphia, Pa.—Book No. 53, devoted to the subject of telpherage, or the trolley system of conveying materials by electric power. Numerous illustrations show the wide range of the system for conveying all kinds of materials, whether boxed, barreled or loose, and whether in the solid or liquid condition; and also indicate the manner in which it is practicable to overcome the interference often presented by driveways, rivers, railroads, streets or other local conditions.

### Boilers

TRAYLOR ENGINEERING COMPANY, New York.—Catalogue devoted to a description of the Hawkes combination boiler, both for power and heating purposes; also digesters, ladles and other sheet-metal products.

THE RUST BOILER COMPANY, Pittsburg, Pa.—Report of tests on the Rust water-tube boiler by Prof. William Kent, with data and results of trials according to the code of the American Society of Mechanical Engineers, showing the high efficiency and capacity of the Rust boiler when using Pittsburg bituminous coal.

### Cooling

EDWIN BURHORN, New York.—Catalogue devoted to the Burhorn and Acme cooling towers for cooling water for refrigerating plants, breweries, distilling-plant condensing steam engines, steam turbines, gas-power plants, etc. Many illustrations of installations are given and data and results of tests.

### Pumps

THE GOULDS MFG. COMPANY, Seneca Falls, N. Y.—A fully illustrated catalogue of triplex power pumps, showing their applications for modern buildings, factories, municipal and general water supply, and other hydraulic problems. Many installations in prominent buildings in New York, Chicago, Philadelphia, Pittsburg and other cities are shown, together with descriptions and specifications of pumps for all kinds of duty.

### Rock Drills

THE J. GEORGE LEYNER ENGINEERING WORKS COMPANY, Littleton, Col.—Bulletin No. 514, devoted to the Leyner steel-sharpening apparatus, as applied to the sharpening of rock drills for mining and tunnel work. The Leyner oil and coke furnaces for welding and tempering drill steel are also illustrated, together with tables of dimensions and weights.

### Gauges

STANDARD GAUGE MFG. COMPANY, Syracuse, N. Y.—Bulletin No. 2, describing the Standard line of pressure and vacuum gauges adapted for steam and hydraulic pressure and for ammonia, sulphite and other fluids. Gauges for air-brake service are also shown, together with recording gauges, clocks, gauge boards and counters.

### Briquetting

JULIUS BORDOLLO, Kingsbridge, N. Y.—Pamphlet discussing the advantages of the Couffinhal system for briquetting coal waste, culm and dust, and producing a commercial fuel. A list of several hundred installations of the system in Germany, France, Belgium, Italy and other parts of Europe is appended.

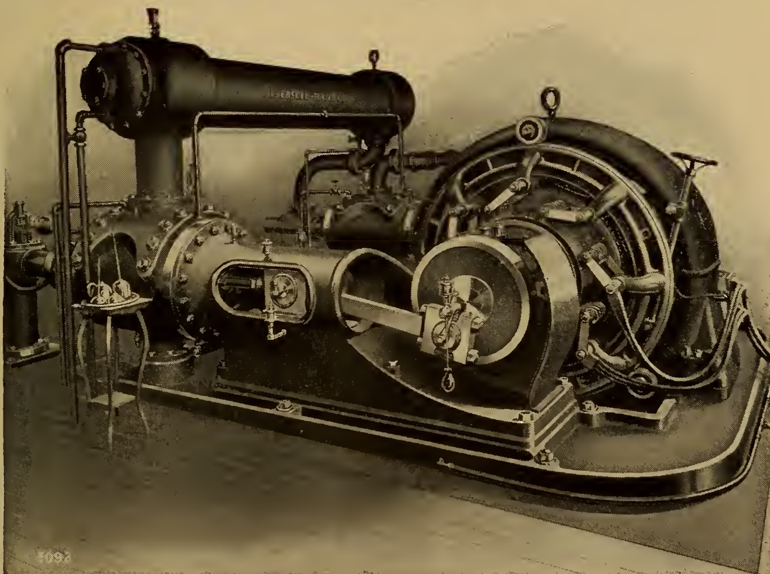
## Electro-Pneumatic Power Transmission

THE power problem is the problem of industrial achievement and material progress. Cheap and readily available power makes the opportunity of enterprise and industry, and when it is appropriated and employed values are produced and wealth accumulates. All our power coming ultimately, as far as we now know, from the energy diffused by the sun, the function of the entire series of operations and devices this side of the sun by which this power is made to do the work, in detailed portions, large or small, of the engineer and the mechanic, may be said to be entirely that of transmission. The development, as we term it, of power by the combustion of coal, the generation of steam and the application of its expansive energy to produce forceful mechanical movement, is only a detail of the transmission series. The employment of falling water which has been drawn up by the sun to turn our wheels is only a less tortuous channel of transmission than the other.

Generally, neither of these two beginnings of the familiar lines of transmission bring the power all the way to the actual work without still other means, the first operation being usually a dividing up and a distribution of the power of the larger initial units. For this end of the work other agencies come into play, and the one most active and prominent—the one in this age insisting upon being first thought of where anything requiring power is to be done—is the electric current. It is scarcely an impertinence now, when electricity is not employed for any new undertaking, for its friends to be inquiring why not. And yet electricity is not best or most effective for every line of power employment. For some important and responsible operations compressed air seems to be, and seems likely to remain, the most desirable and satisfactory; but even here the habit is developing of these two agencies working together and each providing additional employment for the other.

Electricity makes it possible to adapt compressed air economically in many cases and under certain conditions. When, as often now happens, the power is to be transmitted a long distance, and when, after all, it is desirable to use both electricity and compressed air in the final workings, it is not necessary to lay both wires and pipes all the way; and indeed, it would not be practical to carry pipes to such distances as wires are now quite commonly laid. Let the wires carry the power most of the way from the big water power, and then let the electric-driven compressor be located within a reasonable distance from its work. Circumstances must determine the details of this arrangement, and especially the location of the compressor. Generally speaking, if a large volume of air is to be used, it is best to install large units in a suitable power house instead of distributing smaller machines here and there for the saving of some lines of piping. The piping should not be made a bugaboo. There is no difficulty in making and keeping it tight, and the piping makes a cheap reservoir for the air. As the air is always used with more or less irregularity, the fluctuations of consumption can be better taken care of in the concentrated plant than in the scattered and isolated units. The electric air drill has made it possible to use electricity as the sole transmitter of power in mining operations. No lines of piping are employed, the wires leading right to the drill pulsator; and this arrangement, and the success of it, has led to the suggestion now current of distributing small electric-driven compressors in different locations in a mine for driving percussion drills of the familiar air-pressure-driven type. The power cost of such an arrangement would be four or five times that of the electric air drill, not to speak of the many other objectionable features.

# ELECTRIC-DRIVEN COMPRESSORS



Where electricity is cheaper than coal, the electric compressor solves the problem of air power economy. Where there is no actual difference in power cost, the convenience of the electrical unit often recommends it in preference to other types. Its use in productive industry often marks the line between profit and loss.

Ingersoll-Rand electrical compressors combine the best electrical and pneumatic practice. They embody an experience of thirty-seven years, covering the building of nearly a million compressor horse-power. More than 90 per cent. of the electrical compressors in use today are Ingersoll-Rand machines—a fact establishing them as the accepted standards of electro-pneumatic power economy. They bring to the user the best assurance of success.

**AIR TOOLS AND HOISTS** **ROCK DRILLS**

# INGERSOLL-RAND CO.

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| SEATTLE | SAN FRANCISCO | BUTTE SALT LAKE | BIRMINGHAM | DENVER |
| MONTREAL | JOHANNESBURG | LONDON PARIS | DUSSELDORF | MELBOURNE |

V35

### Hoisting Machinery

THE earliest form of machine for lifting a load was probably the lever; a stick or bar was placed beneath a load, and, with a stone for a fulcrum a weight was lifted which the unaided strength of a man could not have moved.

Later, in the history of mechanics, the pulley was invented, and with a rope or twisted fiber it became possible to raise various objects to far better advantage than was otherwise practicable. The windlass naturally accompanied the use of the rope or cable for lifting heavy objects, and when the lower movable pulley was added to this the principle of multiplying leverage was discovered, and the power hoist was practically invented.

Such a machine, however, had many defects. It could not hold the load from running down, and if heavy loads were to be lifted, the number of movable sheaves and consequent bends to the rope consumed much power in friction, and made the apparatus cumbersome and inconvenient. Ropes made of fiber are apt to stretch and become uncertain, and hence chain came into use for various purposes, and in many cranes and power-hoisting devices chain is employed in connection with grooved drums.

The Chinese windlass was an ancient device for utilizing the differential principle by employing two drums of different diameters, but this was of limited application, and remained a curiosity until Weston made it practical by inventing the differential chain block, producing at once a simple and effective hoist; extending greatly the lifting capacity of man, and capable of sustaining the load at any point without involving any additional apparatus.

The differential block remained for many years the leading practical hoisting apparatus for portable service, and in situations where simplicity and moderate cost are essentials, and where the intermittent nature of the work renders mechanical efficiency a secondary consideration, it is still widely used. With the perfection of all mechanical devices, however, it has been realized that higher efficiencies are desirable and attainable, and the result is the production of various types of chain blocks in which the resistance by which the load is sustained is relieved during the operation of hoisting, and called into action only when actually required. This permits the efficiency of the apparatus to be limited only by the resistance of the gearing of the hoist, extending the scope of the portable chain hoist to such an extent that it now forms an important element in many types of cranes and shop installations.

Two types of gearing have been found applicable in the design of chain hoists, the worm and worm-wheel, and the direct spur-gear train. The latter, when properly balanced and combined with a suitable sustaining device, forms what is undoubtedly the most efficient and durable chain hoist yet devised. The former, especially when designed in accordance with the modern proportions of worm and worm-wheel, gives a type intermediate between the spur-gear system and the older differential block, capable of wide application, and extensively used in practice.

The development of the chain hoist, as thus outlined, forms an interesting chapter in the evolution of manufacturing efficiency, an evolution which is largely based upon the increased use of human skill and a relegation of muscular effort to a secondary position, to be performed by machinery wherever possible, and to be assisted by mechanical appliances in every possible manner.

There is no longer any necessity for the skilled mechanic to expend his physical energy in such operations as lifting and moving heavy pieces of work, since the provision of powerful and convenient hoists will always relieve him of such effort.

# How do you do your Hoisting


## In Yale & Towne Chain Blocks

are embodied the final development in lifting mechanism and the highest integrity in Chain Block construction. They lead in efficiency, speed, durability, reliability and universal adaptation to every hoisting requirement.

Triplex Blocks—⅛ to 40 tons. Universally recognized as the most durable and efficient Chain Block made. Have balanced train of spur gearing with large internal gear.

Duplex Blocks—½ to 10 tons. The handiest and safest Screw Blocks made. Have safety guides to prevent slipping of load chains. Bronze worm wheels and steel worms with hardened and ground thrust bearings running in oil.

Differential Blocks—⅛ to 3 tons. Not as durable or easy lifting as the Triplex or Duplex, but safe and twice as durable as the cheaper kind of the Weston Differential Block, because of superior Chain and Sheaves.

Y. & T. Blocks, duplicate parts and trolleys are carried in stock by Hardware, Machinery and Mill Supply Dealers. Write for catalogue.

## The Yale & Towne Mfg. Company

9 Murray Street, New York

### Storage of Energy

IT is generally understood that nearly all methods of power generation must be prepared to meet the irregularities resulting from the varying demand, as well as from other fluctuations. Even with a comparatively steady and uniform load there will arise sudden demands for power, or unforeseen cessations of resistance, and no system which is lacking in elasticity in these respects can be considered as complete or effective.

In the case of hydraulic power this requirement is met by the provision of a storage reservoir capable of retaining a large volume with but moderate variations in level for changes in content. With a steam plant it is well known that boilers containing large volumes of water permit a much steadier pressure to be maintained under varying demands by the engines than those types which are of smaller proportional capacity; and indeed, it is upon this principle that the so-called steam accumulator has been designed to equalize the discharges of exhaust steam from pumping and winding engines and provide a continuous flow for use in the low-pressure steam turbine. In like manner, the electrical accumulator is extensively employed to take care of the peak of the load in power-station service, and thus permit the installation of the average power instead of requiring the prime movers to be sufficiently large to meet the maximum demand.

These examples are familiar; but, in fact, the principle of power storage extends much further. Thus, every variety of fuel represents stored energy measured by its calorific value, and every carload of coal corresponds to a quantity of latent power capable of transportation.

When the question of the long-distance transmission of power by means of electricity was first discussed it was shown that, so far as power from fuel was concerned, the cheapest manner in which energy could be sent from one point to another was in the concentrated form of coal carried by train rather than by wire.

As coal thus represents stored power in transmission when in the car, so it corresponds to stored energy in bulk when in the heap or bin. The great piles of coal in the yards of power stations, waterworks and manufacturing establishments are as much reservoirs of power as the mill-pond or the great hydraulic reservoir. The energy in a body of water is measured by its quantity and its elevation, and the power it can develop is controlled by the rate at which it can be discharged. In like manner the power in a coal pile is measured by the heat units and by the rate at which they can be delivered. The water will flow through proper conduits because it is in the liquid state; the coal can be made to flow both into the pile or reservoir and out of it into the furnaces where the conversion takes place, not by changing its state, but by the use of modern coal-handling mechanism, by the application of automatic and cable railways, by the installation of conveyors, hoppers, chutes, valves and a complete handling system.

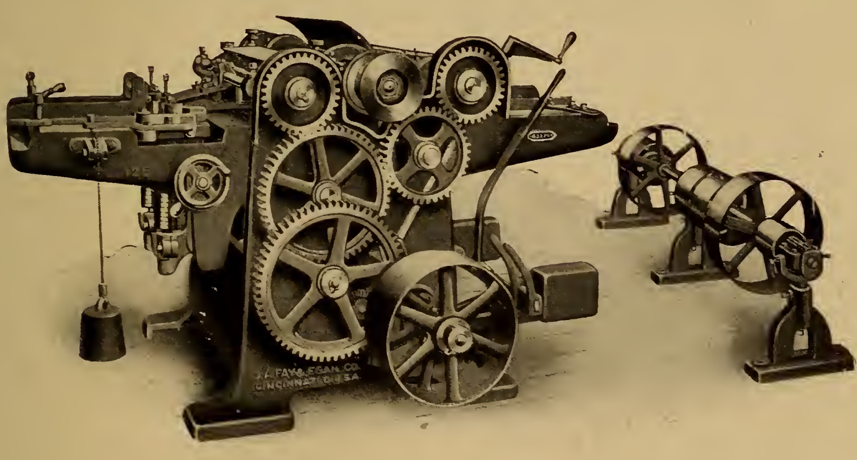
The storage of power in the concentrated form of coal thus provides a method of equalization to meet the fluctuations of demand in a manner entirely adequate to the requirements of modern manufacturing, and every power station thus equipped is prepared for its work to the same extent as a hydraulic station with a full reservoir behind it.

Such a storage system has a commercial value, as well as a technical one, since the plant with full bins is prepared to meet fluctuations in prices or of shortages due to labour troubles or other delays, and thus equalize all the irregularities with which it has to contend, converting a position of dependence upon daily conditions and requirements into one of independence and masterful control.

# Manufacturing News

### A Planer, Matcher and Molder for Small Shops

THE machine shown in the accompanying illustration is manufactured by the J. A. Fay & Egan Company, 226-246 West Front Street, Cincinnati, Ohio, who claim it to be one of the strongest planer, matcher and molders for its weight now made.



PLANING, MATCHING AND MOLDING MACHINE. J. A. FAY & EGAN, CINCINNATI, OHIO

The manufacturers have designed this machine especially for use in small mills. It is strong, compactly built and occupies the smallest floor space practicable.

It is especially adapted to the manufacture of molding, casings, baseboards, etc., beyond any other small machine, because it is fitted with adjustable pressure bars and slotted cylinder.

It will plane on one side up to 24 inches wide and up to 6 inches thick and matches 12 inches wide.

It is almost instantly changed from a planer and matcher to a surfacer, or vice versa.

Further detailed information will be promptly furnished by the manufacturers.

CAMERON STEAM PUMP DRAINING FOUNDATIONS OF THE PENNSYLVANIA RAILROAD TERMINAL IN NEW YORK CITY

**Pumps for Foundation Work**

THE extending importance of concrete for foundation work has led to a corresponding increase in the use of the various mechanical appliances associated with the production and use of concrete. Very often, foundations of this sort involve the handling of large volumes of water, and in many cases the depth of the foundation causes correspondingly high lifts for the drainage water. It is especially necessary for the contractor to be equipped with an ample number of powerful pumps when undertaking the construction of maritime works in concrete, and indeed some systems of sinking reinforced-concrete piles include the employment of the hydraulic jet, especially when such piles have to be sunk in sand, as in the construction of seashore piers and the like.

For such work, and indeed for all undertakings involving the movement of water, the Cameron steam pumps have been found most effective, and their reliability under the most difficult operative conditions has led them to be extensively used in connection with foundation work and drainage.

In the accompanying illustrations are shown two installations of Cameron pumps in the construction of foundations in New York City. One of these shows a characteristic portion of the great excavation forming the underground portion of the new terminal of the Pennsylvania Railroad in New York. As is well known, this great work extends from Ninth to Seventh avenue, and between Thirty-first to Thirty-third streets, and will be reached by tunnels passing under the Hudson and the East rivers, as well as under the

FOUNDATION WORK A1 THE NEW EDISON POWER HOUSE IN NEW YORK CITY. CAMERON STEAM PUMP IN FOREGROUND. MESSRS. SNARE & TRIEST, CONTRACTORS

entire width of Manhattan Island. In this work there has naturally occurred much leakage from the various pipes encountered, besides which the excavation receives large volumes of storm water during the rainy weather. This water is collected in sumps, or drainage pits, thus keeping the main portion of the excavation clear, and the illustration shows a Cameron pump placed upon an upper wall, draining one of these sumps, delivering the water to the sewer, the difference of level being in this case 65 feet.

The other illustration shows a Cameron pump installed for the drainage of the foundation of the Edison power-house construction at 204th street, New York, removing water from a foundation 21 feet deep and 1 foot below tide water, a condition demanding reliability and efficiency in the extreme, and thus forming an excellent test of the suitability of the Cameron pump for service in which the possibility of interruption cannot be considered. The best is none too good for such work, as experience has shown.

### A Modern Automobile Factory

ONE of the handsomest publications of recent appearance in connection with manufacturing operations is that issued by the George N. Pierce Company, of Buffalo, entitled "The Factory Behind the Great Arrow Car." The text of this book has been written by Mr. John Foord, and its substance is a description of the new works of the George N. Pierce Company, with illustrations of the different departments.

It has been said that the good workman never complains of his tools, and it has also been said that the reason is that the good workman will not have poor tools. It is equally true that where one finds the highest-class building, equipped with the latest and best tools, using materials which are the result of keenest modern scientific investigation, there can be no doubt as to the high grade of the product. From such an establishment as Mr. Foord has described in this book, there can come only machines comparable with the place of their origin, and the standing of the Great Arrow Car is a fitting tribute to its home.

### The Philadelphia Bourse

A NUMBER of new exhibitors have been added to the list at the Philadephia Bourse, among whom the following may be mentioned:

The Union Twist Drill Company, Athol, Mass., have taken space to display their line of drills and cutters. They make a very handsome display and they have their office within the space leased.

The Monarch Emery & Corundum Wheel Company, Camden, N. J., have taken space for the display of their line of corundum wheels and shapers, of which they make all kinds. Their goods are in a glass case with a revolving center, driven by a half horse-power electric motor, and it makes a very attractive exhibit.

The Carr-Harrison Tool & Supply Company, of Philadelphia, have taken space and office and will display many of the various lines of goods of which they are agents, as follows: Tool steel, seamless steel tubing, high-speed steel, drills and tool holders.

The Messrs. Daley & Davis, of Philadelphia, have taken space for the display of metal, wood-working and electrical machinery and the well-known American boiler flue cleaner, for which they are the general agents. They also have their office in the space with their exhibit and this makes it interesting for the buyer.

### Recent Allis-Chalmers Motor Orders

THE demand for electric motors in general power application appears to be a pretty good barometer of business activity in all fields just now. Judging from the recent influx of orders for Allis-Chalmers motors of various sizes and for various applications, it would seem that producers are not content to await the settlement of political issues before fortifying themselves against the increased demand for manufactured products which the future will inevitably bring. To take, for example, a few representative industries:

The Schlitz Brewing Company, Milwaukee, has recently purchased twenty standard Allis-Chalmers inductive motors, ranging from 3 to 40 horse power each, for installation in a new malt house just built. The Cudahy Packing Company, at Cudahy, Wis., will install, in addition to its present large line, nine new Allis-Chalmers induction motors in the sausage room, ranging in capacity from 10 to 40 horse power. The Benito Juarez Mines Company, Salinas, Mexico, ordered a full equipment of generators and motors, the latter ranging from ½ to 50 horse power, for the operating of a new gold-stamp mill, all the machinery for which is being furnished by Allis-Chalmers Company. Washburn Crosby Company, at Minneapolis, will install among others a 200-hp. Allis-Chalmers induction motor. The Standard Hosiery Company, of Philadelphia, has purchased twenty-eight induction motors from 1 to 40 horse power in capacity. Libby, McNeill & Libby Company, Chicago, large users of these machines, has placed orders for another line of Allis-Chalmers induction motors in units from 10 to 40 horse power capacity.

### Commutator Brushes

BETTER commutation is what electricians and users of motor brushes are constantly aiming for. It would be interesting to have before one the many different steps that have been taken in the matter of brush making since the old-time strip of copper was used as a commutator brush.

There seems to be quite a general opinion among the inexperienced or little experienced that some one brush if properly made should answer all requirements, no matter what the motor may be or what the voltage may be. This is a mistaken idea, and one that has produced a great deal of trouble.

At the present time the rivalry

among brushes seems to be between carbon brushes and graphite brushes. Both have their uses; in some cases one is decidedly better than the other, and again it is vice versa.

In trolley car use the motors are usually equipped with carbon brushes, and they are found more satisfactory, so far as we can learn, than graphite brushes. A carbon brush has somewhat better conductivity, and where a motor starts under heavy load, acts better than a graphite brush.

On the other side, the graphite brush is a self-lubricating brush, it wears the copper less, and where the voltage is from 250 to 500, apparently gives far better satisfaction than any form of carbon brush.

Then again there are occasions where it is specially desirable to use both carbon and graphite brushes on the same motor, as they are found under certain conditions to do magnificent team work.

It seems to be the opinion of experts that it is necessary to make brushes to suit the type of motor and service conditions under which they are used. We frequently find that a type of brush which gives excellent service on one class of motors fails when applied to another class of motors.

According to one expert, "the essential features in brush specifications are to have sufficient resistance to limit 'cross currents,' sufficient cutting to wear off mica, sufficient lubrication to polish the commutator surface, and be sufficiently hard to give long life without breaking."

Experience shows that the brush which keeps the commutator in the best condition will give the longest service.

The difficulty experienced sometimes with graphite brushes is that the mica, when it gets to be higher than the commutator, will tear and destroy the soft graphite brush, while had a carbon brush been used the hard carbon would have cut down the mica. At the same time, however, the carbon brush would also have cut and would have worn the copper of the commutator. In other words, it is quite conceivable that a brush that would dress the mica might also dress the copper to its detriment and early destruction.

Dixon's graphite commutator brushes have given most excellent satisfaction, but before using them the type of motor and the conditions of operations should be considered.

It may be well to bear in mind that the use of commutator compounds, that is, a compound for dressing a commutator, is gradually disappearing. Commutator compounds are sometimes apt to make short circuit. The present-day practice is to use a brush that is self-lubricating, one which will give a smooth surface and produce minimum wear on the commutator, as well as one that will aid sparkless commutation.

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**Lidgerwood Cableways**

THE Lidgerwood Manufacturing Company has recently issued one of those handsome and complete works which are really entitled to be considered as special engineering treatises, rather than trade catalogues; works which represent the latest and highest types of construction, presented with a wealth of illustration exceeding that of most professional scientific works. The use of the cableway has extended into nearly every department of civil engineering work, both for the removal of material in the preliminary operations and the delivery of the structural parts of the new work, whether of cut stone, concrete, earth or structural steel. These operations are all shown as executed by the aid of Lidgerwood cableways in all parts of the world, including such structures as the New York barge canal, the Chicago drainage channel, the League Island dry dock, the Wachusett dam, the Cataract dam in Australia, the great dams of the United States reclamation service, the New York subway, and innumerable other installations.

### Announcements

The following officers of the Crocker-Wheeler Company, manufacturers and electrical engineers, of Ampere, N. J., were elected July 10: President, S. S. Wheeler; vice-president, Gano Dunn; second vice-president, A. L. Doremus; chief engineer, Gano Dunn; secretary, Rodman Gilder; treasurer, W. L. Brownell; assistant secretary, J. B. Milliken; assistant treasurer, G. W. Bower.

Mr. J. A. Werner, for many years locomotive coaling engineer for the Link Belt Company, has recently severed his connection with that company and assumed charge of the coaling station department of the Jeffrey Manufacturing Company, of Columbus, Ohio. Mr. Werner, who is one of the most extensively known and best qualified coaling station engineers in this country, will make that work one of the most important features of the Jeffrey Manufacturing Company's business.

The Electric Controller & Supply Company, of Cleveland, Ohio, announces that it has changed its name to The Electric Controller & Manufacturing Company, the latter name more truly indicating the nature and scope of its business. The extent of its line of products may be appreciated when it is understood that it includes controllers, both manual and magnetic-switch types, for all purposes; lifting magnets, electric brakes, magnetic switches, solenoids, limit stops, arc welders, crane fittings, knife switches, flexible couplings and the electric faultfinder.

Announcement is made that the Cutler-Hammer Manufacturing Company, of Milwaukee, makers of electric controlling devices, has just completed arrangements whereby this firm will be represented on the Pacific Coast by Otis & Squires, of 111 New Montgomery Street, San Francisco. A large stock of standard Cutler-Hammer controllers will be carried by Otis & Squires, enabling them to make prompt delivery of apparatus. Mr. A. W. Vinson, who has for several years been connected with the engineering department of the Cutler-Hammer Manufacturing Company, has been transferred to the office of Otis & Squires, where his services will be available to those confronted with problems of electric control which cannot be met by the use of standard apparatus.

James S. Watson, manager of the drive chain department of the Link-Belt Company, has transferred his headquarters from the Philadelphia works to the company's chain manufacturing plant at Indianapolis. In his new field he will combine supervision of manufacture with direction of the selling force handling the Renold silent and roller chains.

Mr. T. Kennard Thomson, M. Am. Soc. C. E., etc., consulting engineer for the design and construction of bridges, railroads, foundations, buildings, etc., announces the removal of his offices in New York City to the Hudson Terminal building, No. 50 Church street. Mr. Thomson was graduated from the University of Toronto in 1886, and has had an extensive experience, both as structural engineer with a manufacturing bridge company, and as bridge engineer for railroad companies.

Mr. Charles W. Barnaby, M. Am. Soc. M. E., announces that he has opened an office at No. 309 Broadway, New York City. Mr. Barnaby has had a wide practical experience in steam engineering and in general mechanical engineering. Among the various responsible engagements held by Mr. Barnaby may be mentioned those with the Buckeye Engine Company, the Municipal Electric Light and Power Company, the Phœnix Iron Works Company, the C. W. Hunt Company, and other engineering establishments, besides several years' engineering engagement abroad.

## The Anthracite Coal Supply

IN "Mines and Minerals," Edward W. Parker, of the United States Geological Survey, estimates the country's annual production of coal as far forward as the year 2055. By that time, according to the records up to date, the United States will be using more than two billion tons a year—2,300,000,000, to be nearer exact. The average annual production during the decade from 1916 to 1925 will be about 600,000,000 tons. The total production in 1907 was 480,450,042 tons.

The geologist prophesies that future generations "will have so far developed methods of subduing and utilizing other forces of nature that the need of coal for the production of heat, light and power will, to a great extent, have been eliminated." Until these other natural forces are subdued, however, it appears that there will be enough coal to supply the nation.

Mr. Parker calls attention to the rapid consumption of anthracite and to the fact that the cost of mining it has increased.

"With regard to anthracite," he says, "it must be remembered that, with the advances in sympathy with the general tendency toward higher prices, there is the additional fact that the bonanza coal beds have been practically exhausted, and the mining of the deeper and thinner beds increases the cost, which must be made up, as I have stated, by higher prices."

Mr. Parker doubts "if the production of anthracite will ever greatly exceed the production of 1907, which was about 76,000,000 long tons. When the period of decline does set in," he says, "the decrease in production will be gradual, and some anthracite will be used well into the next century; but it is slowly and surely becoming more and more of a luxury, and we may look for gradually increasing prices as the workings become deeper and thinner beds are drawn upon."

## A Powerful Gasoline Blow Torch

THE "Imp" torch, shown in the accompanying illustration, is a patented device, which will do as much work as most of the larger torches, with the advantage of compactness, simplicity and cheapness.


THE "IMP" GASOLINE TORCH

It is entirely automatic in operation, has no pump or valve, needs no tools, starts with a match and gives a perfectly clean, powerful Bunsen flame for over two hours on four ounces of gasoline.

This device is made entirely of brass metal, highly nickel plated. The size of the tank is 1⅞ inches in diameter by 3⅛ inches high, while the height of the whole torch is only 6¾ inches.

The corrugated neck increases the heating surface to such an extent that the flame of a match easily generates gas enough for starting, after which the perfectly designed mixing tube renders further attention unnecessary.

The "Imp" is sure to receive a hearty welcome from electricians, automobilists, the handy man, and in fact from anyone who wants intense, clean heat, cheaply and quickly, without the inconveniences associated with heavy and complicated devices.

The Frank Mossberg Company, of Attleboro, Mass., are the manufacturers of this torch.

# THE LATEST CATALOGUES

**Bolts.**

Russell, Burdsall & Ward Bolt & Nut Company, Port Chester, N. Y.—Catalogue 1908, of bolts, nuts, rivets, machine screws, etc., giving illustrations of the various styles, tabulated dimensions, weights and prices. The catalogue affords a convenient reference list for engineers and machinists, and shows very clearly the extensive line of products of the manufacturers. A telegraphic code is appended, together with some useful tables for reference.

**Elevators.**

Kaestner & Co., Chicago.—Handsomely illustrated catalogue devoted to electric elevators, showing details of the various types of winding mechanism, with lever, hand-cable, or push-button control. The details of the magnetic control for high-speed operation are described and various designs of elevator cages are illustrated. The elevators shown are adapted for freight and for passenger service, and the catalogue is an excellent contribution to the literature of the subject.

**Milling.**

Pratt & Whitney Company, Hartford, Conn.—Special catalogue of the spline milling machine manufactured by the Pratt & Whitney shops of the Niles-Bement-Pond Company, showing the extent to which the operation of milling slots and oblong holes may be conveniently effected. The spline milling machine is a new tool, the work being carried on a slide traversing between two cutter spindles. It is adapted not only for keyways, but for an endless variety of work, some samples of which are illustrated in the catalogue. The pamphlet, which is a handsome piece of printing and illustrating, contains also descriptions of cutters and cutter-grinding machines.

**Boilers.**

Heine Safety Boiler Company, St. Louis, Mo.—"Boiler Logic," a brief pamphlet setting forth the principles governing the design and manufacture of the Heine safety steam boiler, in which are included the questions of economy of fuel, safety and durability of the boiler, economy in space occupied, and accessibility for cleaning. The construction of the Heine boiler is very clearly shown by detailed illustrations, and its advantages effectively set forth.

**Superheaters.**

Heine Safety Boiler Company, St. Louis, Mo.—"Superheater Logic." This is a companion pamphlet to the preceding, and is devoted to a discussion of the principles involved in the design of an effective steam superheater, with especial reference to the apparatus designed to be installed in connection with the Heine steam boiler. The superheater consists of a system of steel tubes placed by the side of the boiler shell and arranged to be heated by the last passage of the boiler gases, forming an excellent device for abstracting the heat and transmitting it to the steam.

**Pulverizers.**

The Jeffrey Manufacturing Company, Columbus, Ohio.—Catalogue No. 31-A, describing the Jeffrey crushers and pulverizers, showing the swing-hammer construction of the latter and the wide adaptability and usefulness of both machines. Various arrangements of screen-bars for use with crushers are shown, and every provision is made for handling every kind of material. A list of prominent users of these machines is included.

**Fans.**

The Jeffrey Manufacturing Company, Columbus, Ohio.—Cata-

logue No. 26, devoted to a description of the Jeffrey centrifugal fan for the ventilation of mines. The fan is designed for operation at low speeds against heavy resistances, giving a high efficiency, and is capable of handling large volumes of air. It is designed with either single or double inlet, and with the variety of casings shown it is capable of installation in any conditions appearing in the ventilation of mines. The curvatures and positions of the vanes in these fans are the result of a systematic and thorough series of tests made for the purposes.

**Foundry.**

The Whiting Foundry Equipment Company, Harvey, Ill.—General catalogue of appliances for foundry equipment, including cupolas, cranes, ladles, charging machines, tumblers, etc. The products of the company include all details which go to make up complete foundry equipment of the most modern type, the various portions forming the subjects of special catalogues, and the present pamphlet indicating broadly the scope and character of the work of the establishment.

**Locomotives.**

Baldwin Locomotive Works, Philadelphia.—Record No. 65, containing a reprint of a paper upon the Mallet articulated compound locomotive, originally presented before the Engineers' Club of Philadelphia by Grafton Greenough. The paper discusses the development of the Mallet engine from the Fairlie type of articulated locomotive, followed by descriptions of engines of the Mallet type which have been built for American railroads by the Baldwin Company, with details of the special features of construction, such as the articulation of the frame, the sliding bearings, thrust springs, etc., the whole forming a valuable contribution to the subject of locomotive design.

**Refrigeration.**

Vulcan Iron Works, San Francisco, Cal.—Catalogue D, devoted to the subject of the Vulcan refrigerating and ice-making machines. The apparatus operates on the compression system, using liquid anhydrous ammonia, and for refrigeration it is arranged either on the direct or the brine system, while for the manufacture of ice the can or the plate system may be employed. The compressors are arranged either for direct connection to the engine or for belt driving, and of capacity from one to fifty tons. Plans of standard ice-making plants are given, with data concerning stationary and marine installations.

**Digging Machinery.**

The Hayward Company, New York.—Catalogue No. 30. A remarkably handsome publication devoted primarily to the exhibition of the various types of buckets and digging machinery built by the Hayward Company, but actually forming an elaborately illustrated treatise on machinery for digging, excavating, dredging and handling of material. The first portion of the work illustrates the standard orange-peel and clam-shell buckets of the Hayward Company, also scraper clam-shell buckets, bottom-dump and turn-over buckets and scoops. These have been designed for practically every kind of service, and are shown attached to and operated by machines of the Hayward Company and of other manufacturers. In addition to the buckets themselves, the catalogue illustrates a great variety of dredges in actual service, with buckets adapted for digging sand, gravel, mud or blasted rock. Similar illustrations are devoted to excavators, upon ditch, canal, foundation and other work, while the adaptability of the buckets to traveling derricks, locomotive cranes and general handling machinery follows, together with a list of builders upon whose machines the Hayward buckets are used.

**Furnaces**

The Hawley Down-Draught Furnace Company, Chicago.—Catalogue of the Schwartz metal-melting and refining furnaces, using crude oil, fuel oil or gas for fuel, and adapted for making the highest grade of castings in gray iron, malleable iron, steel, copper, brass, etc. This catalogue describes Schwartz melting furnaces in sizes ranging in capacity from 100 to 20,000 pounds per heat, dispensing entirely with the use of crucibles, and effecting a material economy in fuel and labour. Useful data concerning alloys, temperatures and melting are given, rendering the catalogue valuable for reference.

**Anemometers**

Taylor Instrument Companies, Rochester, N. Y.—Pamphlet illustrating the Short & Mason anemometers for the measurement of the velocity of air currents in mines, tunnels, sewers and ventilation systems. The instruments are of the well-known Biram type, made by manufacturers of international reputation, and are fitted with dials reading from 1,000 to 10,000,000 feet.

**Arc Lamps**

Scott Electrical Company, Newark, N. J.—Booklet describing the Scott flaming arc lamps for the production of long arcs of high illuminating power and of any desired color. The various classes of lamps are illustrated and directions for ordering are given. Tests show that, for the same cost of current, the flaming arc, produced from impregnated carbons, gives from ten to twelve times the illumination yielded by the ordinary electric arc.

Fort Wayne Electric Works, Fort Wayne, Ind.—Instruction Book No. 3,032, for use with the Fort Wayne Series A. C. arc systems, discussing installation, connections, starting, and directions for care and repairs. General information concerning lamps, transformers, switchboards and adjustments are included.

**Refrigeration**

The Arctic Machine Company, Canton, Ohio.—Descriptive catalogue of the Arctic ice-making and refrigerating machinery made under the patents of J. & E. Hall, and using carbonic anhydride as the refrigerating agent. The machines are illustrated both as arranged for separate driving or with steam engine included, and in the vertical and horizontal forms. The advantages of carbonic anhydride (liquid carbonic acid) are set forth, and the applications of the machines for cold storage, both for land and marine service, are discussed.

**Brushes**

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Booklet describing the Wirt-type dynamo brush, designed especially for use with low-tension, direct-current motors and generators, alternating-current generators, etc. The brush is made of laminated strips of metal, high-resistance metal being combined with copper laminations, securing at the same time flexibility, long life and freedom from sparking.

**Meter Book**

Fort Wayne Electric Works, Fort Wayne, Ind.—Circular describing a convenient record book for meter readings in connection with the operation of electric stations. The loose leaves have blank meter dials printed on them, and the record is made by marking the positions of the pointers. One leaf will contain the record for one customer for a year.

**Fan Motors**

Fort Wayne Electric Works, Wort Wayne, Ind.—Booklet illustrating Fort Wayne electric fans and motors for desk, bracket and suspension connections. The suspended revolving fan motor is shown, and also a special form adapted for use in telephone booths.

**Motor Boats**

Pierce Engine Company, Racine, Wis. Handsomely illustrated catalogue devoted to the Pierce motors and motor boats, including two-cycle and four-cycle motors, boats for family and sporting use, with descriptions and specifications of the various types.

**Mechanical Products**

Allis-Chalmers Company, Milwaukee, Wis.—Booklet giving general descriptions of the various shops of the Allis-Chalmers Company at Milwaukee, Chicago, Scranton and Cincinnati, together with data concerning the different products, including the following lines of machinery: Electrical, steam, hydraulic and gas power; also mining machinery, crushing and cement machinery, sawmills, flour mills and air brakes. The various works and their products are handsomely illustrated, and the booklet gives an excellent idea of the magnitude and wide range of the commercial and engineering activities of the company.

**Steam Turbines**

De Laval Steam Turbine Company, Trenton, N. J.—Bulletin 501, describing different types of high-grade turbine and motor-driven machinery, including the De Laval steam turbine, centrifugal pumps, turbine dynamos for direct and alternating current, multi-stage centrifugal pumps and turbine-driven blowers. A list of points concerning which information should be given in considering the use of the steam turbine is appended, and the bulletin is handsomely printed and illustrated.

**Coaling**

Williams, White & Co., Moline, Ill. — Special catalogue describing coaling stations for coaling locomotives, containing specifications and construction drawings, and including standard automatic coal-chute pockets, weighing devices and general equipment. Illustrations of a number of railway coaling stations are included.

**Pumps**

The Watson - Stillman Company, New York.—Catalogue No. 71, devoted to hydraulic pumps and accessories for use with hydraulic presses, jacks and similar machines. This is a very complete catlogue of portable and stationary pumps capable of developing pressures as high as 6,000 pounds per square inch. Pumps for hand power belt-driving or electric power are shown, and much useful information relating to such machines appended.

**Gear Cutting**

Gould & Eberhardt, Newark, N. J.—Catalogue 907, describing entirely automatic gear and rack cutting machinery. The various machines are handsomely illustrated, the line of the new-type design comprising machines for cutting spur gears from 36 to 84 inches in diameter, and for cutting bevel, skew and face gears in sizes from 36 to 74 inches, besides a smaller machine for gears up to 22 inches diameter. Automatic rack cutting machines from 6 to 10 feet capacity are also shown. Horizontal gear-cutting machines for large work and coarse pitches are made in 10, 15 and 20-foot sizes, for faces from 20 to 36 inches. Specifications for the various machines accompany the illustrations, the whole forming an admirable list of important tools devoted to the subject of gear cutting.

**Engines**

Minneapolis Steel & Machinery Company, Minneapolis, Minn.—Handbook for use in connection with the Corliss engines built by the publishers, giving the names of the various parts of the engines and detailed instructions for setting the valves. Tables of dimensions, power, economy, etc., are appended, together with power-transmission tables for shafting, belting and rope-driving.

## Rope Transmission

THE use of rope for the transmission of small powers is an old device, and it is probable that the rope is older than the belt in this respect. With the development of the steam engine, however, and the increase in the amount of power delivered from the prime mover to the first shaft, the advantages of leather belting seemed to the general mechanic more desirable than rope, but in recent years the use of rope has increased, and for certain situations it has been found to possess advantages over belting.

Like all other mechanical devices, rope transmission has its applicability to certain locations, and it has been found to give excellent results when intelligently applied, while, when used without proper judgment and knowledge, it has been condemned. It is best used for the transmission of large amounts of power when smooth and quiet running are essential, and when economy in first cost is of importance. When the shafts cannot be precisely aligned, the rope system has distinct advantages over belting, and the judgment of the engineer should be relied on to determine which system is the better for any special case under consideration.

So far as the question of rigidity is concerned, there is little difference between rope and belting, but experiments show that there is a marked reduction in the friction loss in the use of rope over belts for the transmission of power. A rope two inches in diameter is the practical equivalent of a double leather belt ten inches in width, and it has been shown that in these two cases the loss from creeping and stiffness for the rope is about one-half that for the belt.

It is important that a rope transmission shall be properly arranged, if the operation of the installation is to be satisfactory. Reverse bends should be avoided, since it has been found that the life of a rope with reverse bends is only about three-fourths that of one in which the bends are always in the same direction. The diameter of the pulleys also has an important influence upon the wear of the rope, and the larger the sheaves the less the internal wear of the rope. For transmission systems, the diameter of the sheaves should be not less than forty times the diameter of the rope, and as much larger as it is practicable to make them.

There are two separate causes of the wear of rope in a transmission system: the sliding of the fibres upon each other in the bending of the rope, and the friction due to the sliding of the rope upon the grooves of the pulleys. These causes may be reduced by several methods: by increasing the distance between pulleys, and thus causing each point of the rope to touch the sheave less frequently, and by using pulleys of large diameter, and thus causing the rope to be bent to an arc of larger radius. It is also important that the grooves in the pulleys should be highly polished, so that the fibres of the rope may not be injured by such sliding as is unavoidable. Tool marks on the pulleys, or defects, such as blow-holes in the castings, are most injurious to the rope, and cause it to be rapidly cut out.

The power transmitted by ropes may be computed upon the basis that, at all speeds, a rope one inch in diameter should have a working stress of 200 pounds, this being about one-twentieth of the strength of the splice.

The action of centrifugal force diminishes the power transmitted to such an extent that at speeds between 4,500 and 5,000 feet per minute the maximum power is attained, and beyond these speeds no gain in power follows any increase in velocity. At these speeds a one-inch rope will transmit about 13 H. P., and a two-inch rope about 54 H. P., and for greater powers a corresponding number of ropes may be used.

# Manufacturing News

## French Brill Company Organized

COMPAGNIE J. G. Brill, 14 Place de Laborde, Paris, France, has been organized to handle the business of the J. G. Brill Company, Philadelphia, in France and Spain. Brill trucks and equipment have been largely used for a number of years in Paris and throughout France and Spain, and the formation of the French Brill Company is indicative of the growth and magnitude of the Brill interests in these countries. A plant is to be established, and Brill trucks will be built by French workmen, under French supervision and with French machinery.

As an indication of the extent of the use of Brill types of trucks in France, it may be said that the Brill No. 21-E type is in general use wherever 4-wheeled cars are operated, and that the Maximum Traction and short-base pivoted types are well represented in Paris and other large cities. The high-speed truck of the No. 27-E type has met with the approval of French railway officials and is in service on lines running out of Paris.

The solid-forged side frames used in the construction of all types of Brill trucks have had much to do with the high favor in which these trucks are held in France, and the foremost French truck builders have followed the practice. The stability and easy-riding qualities of the Brill single-truck have commended it for use under the double-deck cars still used on a number of systems. In the larger cities the Maximum Traction truck is repeating the remarkable success it has obtained in the United States and Great Britain. For faster and heavier traffic the equalized short-base truck of the No. 27-G type, which the builder claims is used in larger numbers in the United States than any other one type, is coming into vogue in suburban service. The decision to erect a plant and construct trucks in France is apparently a wise one and well warranted by the large demand and the excellent reputation established.

Compagnie J. G. Brill, 14 Place de Laborde, Paris, will handle all of the business for the J. G. Brill Company in France and Spain, which has heretofore been cared for by Jacques Worms, 27 Rue de Courcelles, and all correspondence relating to French or Spanish business should be addressed to the first-named company.

SIROCCO FANS INSTALLED ON THE ROOF OF THE HOTEL ASTOR, NEW YORK

### The Sirocco Fan

THERE has just been completed on the roof of the Hotel Astor in New York City a fan installation of an unusual character. The installation consists of two 66-inch single inlet Sirocco fans, running on the same shaft. This shaft is fourteen feet between bearings.

The fans draw from a common intake chamber 5 feet 8½ inches wide. They are direct connected to a 35-horse-power motor. The capacity of the fans is 50,000 cubic feet of air per minute each, against a three-quarter inch water gauge. The flue through which the fans exhaust is of brick. The illustration showing the principal features of the installation was made prior to the bricking-up of the central intake.

The light weight and small size of the Sirocco fan for the heavy duty required made it possible to mount the fans on the same shaft, thus saving not only in cost of installation but in power.

### Morison Suspension Furnaces for Internal Furnace Boilers

DESIGNERS and builders of boilers, as well as engineers generally, will be interested in the seventh edition of a book, entitled "Morison Suspension Furnaces for Internal Furnace Boilers," just issued by The Continental Iron Works, Borough of Brooklyn, New York City.

The book deals with the use of the Morison Suspension Furnaces, of which the Continental Iron Works is the sole manufacturer in the United States, in connection with land boilers only, in contradistinction to the application of Morison Suspension Furnaces for marine purposes. It is a finely compiled and printed volume of nearly seventy pages, bound in a serviceable cover.

There is a fund of valuable data, with numerous illustrations, including a number of important installations of Internal Furnace Boilers using Morison Suspension Furnaces,

together with details of design and construction, tables of pressure and thickness, and rules for calculating same.

The designs shown are for land boilers ranging from 50 horse-power to 300 horse-power, and are intended to meet general requirements, it being explained that where boilers are designed to work under other than normal conditions the designs are offered by way of suggestion only.

A form of specification for internal-furnace tubular boilers, which accompanies the designs, should prove an important aid.

In the latter part of the book is a partial list of installations of internal furnace boilers, fitted with Morison suspension furnaces, many of which are repeat orders, demonstrating the satisfaction this type of steam generator gives.

This is followed by illustrations and full information regarding the Morison patent furnace fronts and doors for economical and rapid firing, and which are also made only by The Continental Iron Works.

Engineers, architects and boiler manufacturers will find this book of great assistance to them in the design and lay-out of steam power plants.

The book is printed by H. Edwards Rowland, New York City.

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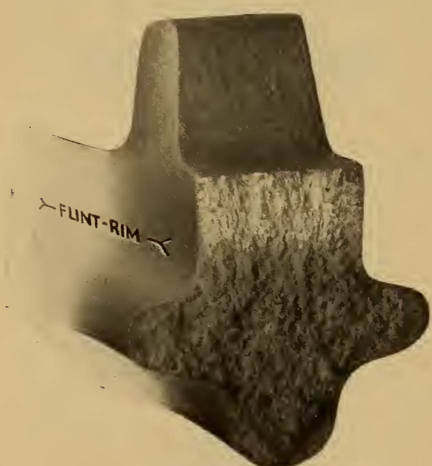
**Briquetting**

THE United States Geological Survey has recently issued a Bulletin, No. 343, reporting the results of investigations upon binders for coal briquets, made at the fuel-testing plant at St. Louis. The commercial side of the problem is first examined, together with the characteristic properties of good briquets, after which a detailed report of the behaviour of briquets made with various binders is given. The cost of briquetting is shown to range from 30 to 50 cents per ton, and the heating value of the fuel is about the same as that of the lump coal from which the dust was derived.

**An Improved Chain Sprocket Wheel**

IN the use of link-belt transmission for connections in machinery applied to the handling of abrasive materials, the working conditions are exceedingly severe, and with wheels of the regular cast-iron type, wear is apt to become excessive. In order to meet the demands for this service, the Link-Belt Company, of Philadelphia, Chicago and Indianapolis, has produced a new type of sprocket wheel, in which the teeth and portion of the rims exposed to wear are hardened to a considerable depth, the surfaces being also made smooth and uniform. This hardening of the working surfaces naturally prolongs the life of the sprocket wheel itself, and it is found also to increase the life of the chain, since the original accuracy of the fit between the links and the sprocket teeth is maintained, and the parts thus retain their proper relations much longer than would otherwise be the case.

The trade name ≻ Flint-Rim ≺ has been coined for this type of sprocket wheel, this name having also been copyrighted by the manufacturers, and the new wheels are now ready for the market in most of the active sizes of the Ewart type of chains.



CROSS-SECTION OF FLINT-RIM SPROCKET WHEEL

## An Improved Push-Button Switch

IT is well known that the tendency in mechanical improvement is from the complicated to the simple, and that most devices are produced first in the more intricate forms, while experience enables important simplifications to be made. An excellent example of this fact appears in the very ingenious push-button switch recently brought out by the Cutler-Hammer Mfg. Co., and shown in the accompanying illustrations.

In general, an electrical switch must consist of three elements: an external actuating member, in order that the motion may be imparted to the internal mechanism; a spring member, to insure a positive and quick make and break; and a contact member. Many switches have these elements included in a quantity of other mechanism, but the new Cutler-Hammer switch has three parts corresponding to these three essential elements, and no more.

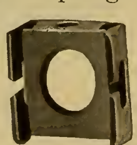
Briefly, the switch, when opened, is found to contain the actuating member in the form of a push bar, extending clear through the switch;

LAVA PUSH BAR

also a small helical steel spring, formed into a coil, as shown; and

COILED STEEL SPRING

a moving contact piece, through which the contact piece passes, and in which the coiled steel spring is carried.

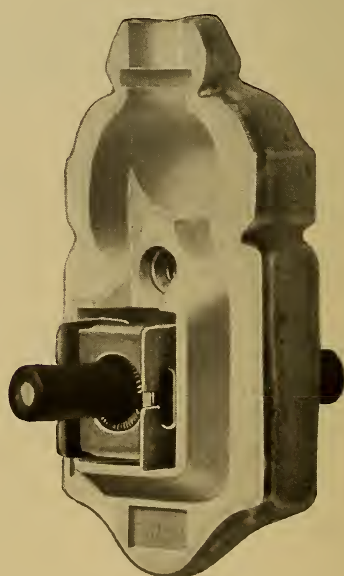


MOVING CONTACT PIECE

When one end of the push bar is pressed, the circuit is opened with a

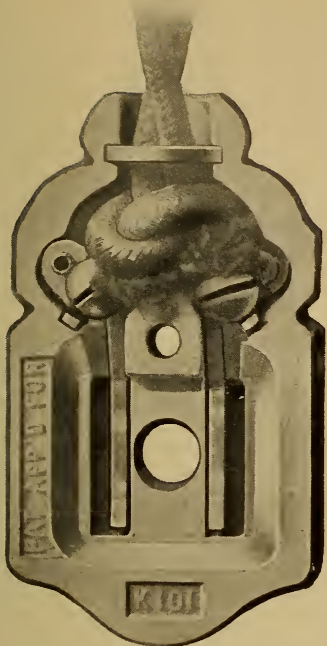
POCKET MODEL OF CUTLER-HAMMER SWITCH

quick snap; when the other end is pushed the circuit is opened with an equally quick snap. The lava push-bar moves back and forth through the switch in a straight line, without possibility of strain, and with a minimum of friction. The coiled steel spring, carrying the contact



MECHANISM OF PENDENT SWITCH

piece with it, snaps back and forth with the same positive, quick motion, whether the movement of the push-bar is fast or slow. The contact piece cannot be moved part way and allowed to slip back again, an action which draws an arc which burns the contacts and eventually destroys them. The internal mechanism does not respond until the widest portion



INTERIOR OF PENDENT SWITCH

of the push-bar slips through the coiled spring, and then the contact piece slips instantly over to the other side. The action of the switch is difficult to be appreciated without an inspection, and hence the manufacturers have produced a little working model, which shows the operation most clearly, and they announce that they are prepared to send one of these little models free on request.

This ingenious push-button mechanism is manifestly adapted to innumerable applications. The illustrations show the interior of a pendent push-button switch on this principle, including the convenient arrangement of the porcelain body, providing for knotting the flexible cord, and enabling access to the interior to be attained by the removal of a single screw. The switch is also made in a socket for incandescent lamps, as well as in bases for surface attachment.

These switches are included among the many products of the Cutler-Hammer Co., Milwaukee, Wis., to whom all inquiries should be sent.

### Ashes for Pillars in Coal Mines

IN some of the anthracite coal mines of northeastern Pennsylvania ashes are being used as pillars to prevent cave-ins. Flushed into the spaces formerly occupied by coal, the ashes form a solid mass when the water drains off, capable of holding up the earth and rock above. Thus they enable the miners to "rob pillars"—to take out coal which they had been forced to leave as supports.

This device is illustrative of the contrast between highly developed mining practices of to-day and the wasteful methods that once prevailed. Then the object was to get as much coal out of the ground as possible, and little thought was given to the future. Now, though, experts have begun to predict the date when there will be no more anthracite; and the mining company of to-day is as careful of conservation as of immediate production.

A mine just outside of Scanton, Pa., is near to a big boiler plant which consumes three hundred tons of coal daily. Naturally, a large supply of ashes is created in the fire-boxes beneath the boilers. It is estimated that about fifty tons of ashes a day are sent down into the mine.

Water pumped from a nearby mine is used for the flushing. Running through a wooden trough, it reaches a tunnel that passes beneath the ashpits. This tunnel slopes at a grade of three-eighths of an inch to the foot. At intervals the ashes are shaken into it from above.

The flow of the water carries the ashes to a borehole, leading straight down through the ground to the mine. At the bottom are pipes leading to the worked-out places, which are to be filled. Through the pipes goes the torrent of ashes and water, and the ashes are piled into the abandoned "breast" or gangway, while the water seeps and drains away. Gradually the pile of ashes grows, until it reaches from floor to

roof. Then it becomes hard and firm. Nearby have been left pillars containing hundreds of tons of coal. When the new ash-pillars are large enough to be safe supports, the coal can be taken out.

It is a costly process. The piping is worn out very rapidly by the sulphur, which is always present in mine water, and therefore has to be replaced frequently. The economy is one the benefits of which are more for the future than for the present. Owing to the rapid exhaustion of the richer and more easily mined veins, it is necessary to use all means, no matter how expensive, to make the remaining coal available.

### Direct Air-Pressure Pumping

THE use of direct air pressure for raising water from wells is by no means new, but there has been a lack of reliable information as to the relations of the amount of air used to the volume of water raised to a determined height. For this reason the experiments conducted by the Westinghouse Air Brake Company, at its work at Wilmerding, Pa., are of value and interest, and from a report of these tests, recently received, some abstracts will be found useful.

As shown in the illustration, the method by which the air is used is that of delivering a jet of air under pressure into the lower end of an open discharge pipe, this discharge pipe being submerged for the lower portion of its length, the upward current of mingled air and water carrying the discharge to the top of the pipe. When the depth of water in the well is not sufficient to permit of the proper ratio between the submerged and the open portions, the arrangement shown in the illustration may be employed, the lift being divided into several stages.

The Westinghouse tests were made on a driven well 174 feet in depth, in which the surface of the water was from 16 to 20 feet below the

DERRICK OVER DRIVEN WELL AT WESTINGHOUSE AIR BRAKE WORKS, WILMERDING, PA.

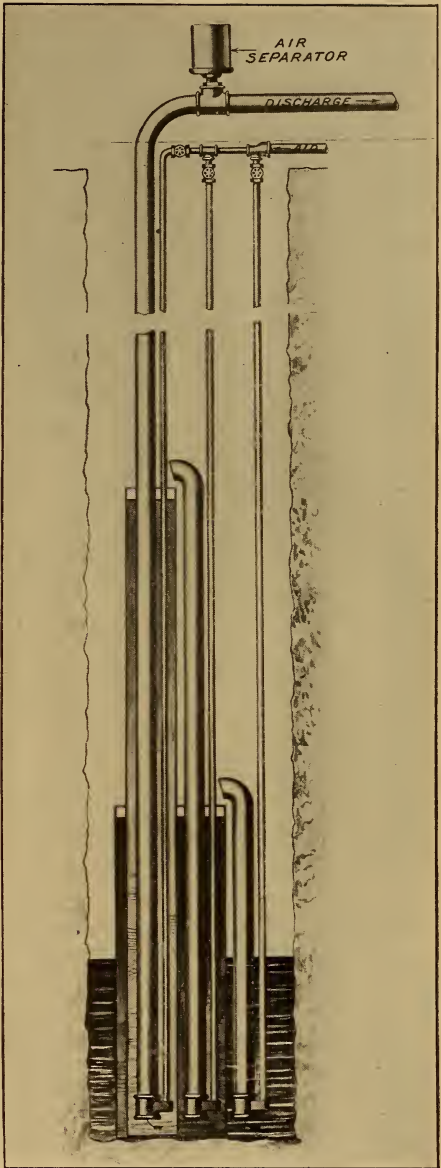
surface of the ground. An oil-well derrick was constructed over the well, as shown in the illustration, this enabling various lengths of pipe to be used and affording protection for the instruments and observers in making the tests. The air supply was furnished from the Westinghouse Air Brake Works at the pressure of 140 to 160 pounds, and a system of tanks enabled the air and the water to be accurately measured, while the pressure delivered to the well was also capable of variation and control.

Nearly eighteen hundred tests were made, covering from 350 to 400 different combinations of discharge-pipe lift and submergence. From the figures obtained in these tests, curves were plotted showing the variation of cubic feet of air used per gal-

lon of water raised, and the gallons of water delivered per minute for the different ratios of lift to submergence. From these curves it was found that the cubic feet of air used per gallon of water raised, and the gallons of water delivered per minute, are practically the same for each ratio of lift to submergence for any submergence of a given size of discharge pipe. For example, a lift of 10 feet and a submergence of 20 feet will take the same amount of air per gallon, or lift the same number of gallons per minute, as a lift of 100 feet and a submergence of 200 feet, the size of discharge pipe being the same. In both these cases the ratio is identical, while the submergence in the latter is ten times as great as that in the former. Consequently it is only necessary to consider the ratio of lift to submergence and the size of discharge pipe.

It was also found that, for a given size of discharge pipe, the gallons of water raised per minute decrease as the ratio of lift to submergence increases. Also, the cubic feet of free air per gallon of water raised increases as the ratio increases for a given size of discharge pipe, and for a given ratio it decreases as the size of discharge pipe increases.

As regards the air pressure required, it was found that the smallest pressure possible that would give a continuous flow from the well was the proper pressure to use. It was found that if the air pressure was choked down slightly below this point the water would come out intermittently in spurts, and the air required per gallon was slightly less than with the continuous flow, but the water delivered was considerably less. On the other hand, if the air pressure was gradually increased above that just required to give a steady flow, the quantity of water delivered would increase somewhat, but the air per gallon increases in a greater proportion and, as the air pressure is further increased, the gain in the quantity of water delivered grows less until at a certain point it stops, and from then on the water delivered decreases in amount.



ARRANGEMENT OF AIR PRESSURE PUMPING APPARATUS, WILMERDING, PENN.

It is very easy to regulate the air supply by the sound of the discharge. The point at which the flow becomes steady is quickly recognized.

From the results obtained it would appear that for a given lift, the

further down in the well the submergence is made the more economical the result would be. This is true as far as the well is concerned, but it must be considered that the greater the depth of the air inlet, the greater the air pressure must be, and consequently the more horsepower must be employed to compress the air. The quantity of air required to operate the well decreases as the depth is greater, while the horsepower required to compress a cubic foot of air increases with the depth. A curve representing the horsepower per gallon of water raised for varying depths and constant lift will at first decrease as the depth increases, until it reaches a minimum point, after which it increases. This point represents the most economical ratio for the given lift. To learn where this point would be, some tables and curves were made which gave the horsepower per gallon of water raised for the different lifts and different sizes of pipe, with various ratios of lift and submergence, from which it appears that the most economical ratios for a given discharge pipe decreases as the lift increases, and for a given lift they increase as the discharge pipe increases.

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### Concrete-Pile Foundations at the Denver Auditorium

IN the construction of the Auditorium at Denver, Colorado, the scene of the recent Democratic National Convention, whose completion was rushed in order to accommodate the delegates, concrete was extensively employed, particularly in the foundations, which consist of concrete piles. The original plans called for spread foundations for most of the building, with the exception of one corner of the structure which was to rest on wood piles. This corner is over a fill over the old bed of Cherry Creek. After the plans had been drawn and the contract awarded, it was decided to use Raymond concrete piles in place of the wood piles to support that part of the building resting on the fill. The concrete piling as placed in this location proved so satisfactory that the architect later decided to have a uniform foundation and to use Raymond concrete piles for all of the piers carrying the arches; 398 Raymond piles were used in this work. In the filled portion of the site, the piles average about 19 feet in length and under the rest of the building they were driven to a penetration of about 8 feet, at which point they encountered a cemented gravel formation. Robert Willison, city architect of Denver, designed the building. Henry W. Schluetter, of Chicago, was the general contractor.

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### Personal

Mr. J. G. Holcombe has resigned the position of division engineer in charge of the Municipal Engineering Division of the Isthmian Canal Commission in Panama, taking effect September 1, 1908, to accept the office of Chief Engineer and Director of Public Works of the Republic.

Mr. Holcombe, a Virginian by birth, has spent years in the tropics, having been chief engineer of the Philippine government when Secretary Taft was governor of these islands. He has had a wide range of experience in railroad, water works, sewers, road building and concrete construction work, and his forceful and resourceful methods have been frequently put to the test in the great engineering undertakings he has successfully accomplished so far from the base of supplies.

Much credit is due Mr. Holcombe for the health conditions at Panama, for his tireless efforts in bringing to a successful conclusion the water works, street paving, sewer building and other public works which Americans did under the treaty between the United States and the Republic of Panama, and which have been so important in bringing about the present low death rate now existing on the Zone.

The Panama Republic, under the wise leadership of the new President, Senor Obaldia, is fortunate in obtaining such an excellent American engineer to direct her future public works development.

Good roads and good emigrants will do much to develop Panama, and Mr. Holcombe is master of the situation as to the natural resources of the Republic of Panama and their needs.

### Columbia University

Columbia University will offer at night during the year 1908-09 twenty evening courses, specially adapted to the needs of technical and professional workers. This includes work in applied mechanics, applied physics, architecture, electricity, fine arts, industrial chemistry, mathematics and surveying and structures. The work begins on October 26, 1908, and continues for twenty-five weeks. A full description of the courses is contained in the Announcement of Extension Teaching, which may be obtained on appplication to the Director of Extension Teaching, Columbia University, New York City.

### Massachusetts Institute of Technology

THE demand for young men, with a more extended and a deeper training in electrical engineering theory than can be obtained in an undergraduate course, has led the Massachusetts Institute of Technology to emphasize its graduate courses. These graduate courses lead either to the degree of master of science for young men who propose to spend one year of advanced study of electrical engineering, or to the degree of doctor of philosophy, or doctor of engineering, for young men who are able and propose to spend longer periods in their advanced study and research. The degrees of master of science and doctor of engineering are particularly applicable to students following electrical engineering studies, and lectures, seminars, and other advanced instruction for students who are candidates for the doctor's degree will be well under way in the electrical engineering department during the next school year. In addition to students who will follow the course leading to the degree of master of science, candidates who will follow the work leading to the degree of doctor of engineering have already arranged to next Fall begin this work at the Institute of Technology. The advanced work leading to the doctor's degree may follow in its major part either the lines outlined by Professor Jackson's lectures on the Organization and Administration of Public Service Companies, or by Professor Clifford's advanced course of Alternating Currents, as the individual student may choose, and it is expected to be accompanied by such other work as may be chosen by the individual students. It is believed by the faculty of the Massachusetts Institute of Technology that engineering students of particular ability can well afford to spend from one to three years of special advanced study under competent instructors along the lines of engineering theory and practice, and that such students will profit largely from the results of such study. Indeed, this seems to be proved by the experience of numbers of engineering students who have gone through courses of advanced study in engineering or scientific schools either in this country or abroad. The schools of foreign countries were doubtless formerly in advance of the American schools, for the purpose of advanced study in engineering and applied science, but it is believed that this condition no longer prevails. The advanced courses in electrical engineering at the Massachusetts Institute of Technology are planned particularly with a view to meeting the needs of such students as have hitherto found it necessary to go to foreign countries for advanced engineering instruction.

# THE LATEST CATALOGUES

### Machine Tools

Niles - Bement - Pond Company, New York.—Special catalogue of Niles boring mills, giving the results of fifty years' experience in the manufacture of these tools, and listing and illustrating sizes from 30 inches up to 20 feet. This is a remarkably handsome publication, both as regards engravings and typography, being one of those proprietary publications which possess a permanent value for the engineer and manufacturer. The larger machines are designed with a degree of massiveness suitable to meet the heavy stresses due to the use of high-power tool-steel, and are arranged for either belt-driving or for electric motors. A number of useful attachments for the mills are shown, for chasing, slotting, independent boring, etc., practically covering the entire range of uses of such machines.

### Lubrication

Joseph Dixon Crucible Co., Jersey City, N. J.—Booklet devoted to the subject of the applications of Dixon Flake Graphite to practically every lubricating purpose. This little pamphlet, which is of convenient envelope size, has each page devoted to some particular phase of the graphite subject, including the lubrication of gas and steam engines, machinery, joints, etc. The advantages of graphite as a lubricant are effectively set forth, and some very useful general information concerning lubrication included.

Graphoil Lubricator Company, Brooklyn, N. Y.—Pamphlet catalogue of Graphoil lubricating specialties, describing and illustrating a variety of graphite cups for use with different lubricating cups. These graphite cups are devised so as to deliver a determinate amount of graphite with each drop of oil, thus enabling the advantages of graphite lubrication to be attained in connection with the use of oil. Lubricators for steam and gas engines are shown, as well as special forms for locomotives and for journal bearings.

### Gauges

Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.—Leaflet illustrating Columbia recording pressure gauges, outside-spring indicators, thermometers and indicating and recording speed-indicators and tachometers.

### Combustion Engines

Lackawanna Manufacturing Co., Newburgh, N. Y.—Pamphlet catalogue containing details concerning Lackawanna valveless engines for motor boats, together with a practical description of combination boat equipments and the fixtures for correct installation. The line includes engines from 2½ horse-power up to 45 horse-power, with from one to six cylinders. The engines are of the two-cycle type, designed with an especial view to simplicity and freedom from complications, and are well adapted for every variety of boat. The builders devote themselves to the manufacture of engines only, including complete outfits, ready for installation.

### Welding

The Industrial Oxygen Co., New York.—Brochure entitled "The Weld that Held," and devoted to a description of the process of joining metals by autogenous welding by the employment of the oxy-acetylene blowpipe. Especial emphasis is laid upon the convenience of the material "oxygenite," from which a supply of oxygen may be readily obtained for use in the blowpipe. Illustrations of the apparatus are given, and examples of the variety of work which may be accomplished by its use in welding and cutting.

**Air Brakes**

The Westinghouse Air Brake Co., Pittsburg, Pa.—Instruction pamphlet No. 5034, devoted to the Type L triple valve, an improved quick-action valve intended especially for use with the Westinghouse air brake on high-speed passenger trains. The construction of the valve is explained by the use of sectional drawings, the various parts being numbered for reference, and its operation, installation and maintenance clearly shown. Although intended primarily for instruction purposes, the publication is interesting to every engineer as describing an example of modern mechanical ingenuity.

**Gas Engines**

Wisconsin Engine Company, Corliss, Wisconsin.—Folder announcing the readiness of the company to supply the Sargent complete-expansion gas engine, in units up to five-thousand horse-power. The company has acquired control of the Sargent patents for double-acting, horizontal tandem gas engines, and is prepared to instal them in cases where the highest fuel economy is required. The company is also prepared to supply Corliss steam engines as heretofore, especially in large units.

**Current Rectifier**

General Electric Company, Schenectady, N. Y.—Folder illustrating and describing a special design of mercury-arc rectifier for changing alternating current to direct current. This particular apparatus is designed for use with the arc lamp as applied to moving-picture machines, enabling a steady and efficient direct-current light to be obtained from alternating circuits of voltages from 200 to 240, and of any frequency from 40 to 140 cycles per second. The apparatus is portable and convenient, and can be set up anywhere with the moving-picture machine.

**Testing**

The Shore Instrument & Mfg. Co., New York.—Descriptive pamphlet of the Shore Scleroscope, for testing the hardness of various metals. The apparatus operates by recording the rebound of a small drop upon the surface to be tested, and it is adapted for direct use in the shop upon work under construction. The use of the apparatus is described in dialogue and its practicability well set forth.

**Fireproofing**

The General Fireproofing Company, Youngstown, Ohio.—Catalogue of various kinds of metallic reinforcements for use in connection with concrete fireproof construction. The materials include cold-twisted lug-bars, pin-connected girder frames, expanded-metal mesh, wire-fabric reinforcement, herringbone steel studding, and trussit reinforcement for roof slabs. Illustrations of "allsteel" doors, window-casing and trim are given, also steel shelving, desks and general office furniture.

American Steel and Wire Company, New York.—Report by Professor Ira H. Woolson, of Columbia University, of tests made upon a triangular reinforced concrete floor-system, constructed by the American Steel and Wire Company. The tests were conducted at the fire-testing station of the university, in co-operation with the city building bureaus, and in presence of representatives of the building bureaus of Philadelphia and Providence, and the result of the successful trials was the official approval of the system.

**Boiler Inspection**

Maryland Casualty Company, Baltimore, Md.—Pamphlet reprint of a paper presented before the International Association of Factory Inspectors, at Toronto, by J. W. Rausch, superintendent inspection division, upon the personal factor in connection with the care and inspection of boilers and machinery.

**Compressed Air**

IN the course of his classical researches into the steam engine and other prime movers, Professor Rankine showed the great theoretical advantages of the air engine, as compared with motors using a fluid such as steam, which changed its state from the gaseous to the liquid form during the development of active energy from heat. The air engine, in the forms in which he considered it, however, never became a commercial success, although some of the principles upon which his analysis of it were based enter into the operation of the modern internal-combustion engine. Nevertheless the advantages of the elasticity of air, in connection with the transmission and application of power, have acquired great mechanical and commercial importance, and the air compressor, in its latest and highest types, together with the numerous useful machines for the application of compressed air, has become an accepted manufactured product, comparable in magnitude and importance with the steam engine.

It is especially in connection with the transmission of power to certain classes of operative tools that the air compressor has found successful application. The rock drill, it is true, is often operated by steam taken directly from the boiler, but this is in cases in which the distance between the generator and the operative machine is comparatively short and the temporary nature of the work renders the losses by leakage and condensation relatively unimportant. In extensive mining work, in important tunneling operations, in the great majority of cases compressed air is employed, its use carrying with it absolute assurance against the serious loss from condensation accompanying the use of steam, together with freedom from excessive heat, annoying drip of water, and minor inconveniences well known in practice.

In the machine shop the air compressor has become an accepted element in the modern plant. Many small tools, such as portable drills, riveters, chipping tools, etc., operated by compressed air, form essential parts of the outfit, and the ability to take the tool to the work and perform minor operations directly under the hand of the skilled workman has practically given such workmen the opportunity of extending their personal skill far beyond the capacity of the hammer, chisel, and file with which they acquired it. Even in such a minor function as that of blowing away the accumulation of chips and dust beneath the cutting tool in the machine, the provision of a supply of compressed air throughout the shop has demonstrated its value, and the mere knowledge that a supply of air is "on tap," so to speak, suggests its application in many labor-saving ways. The modern caisson system for sinking foundations is dependent upon the air compressor for its existence, whether the work be on land or under water. The great bridge and the tall building depend alike upon the possibilities of the application of compressed air for their foundations and for the mechanical riveting of their structural-steel members.

All these applications of compressed air involve the design and commercial production of the machines by which the air under pressure may be economically produced, a department of engineering which demands knowledge and experience of the highest grade, both in the principles of thermodynamics and in the fundamentals of machine design. Different conditions demand machines suited to the special service required; the compressor must be adapted to the mine, the quarry, the workshop, and the portable equipment of the contractor; in short, it must be the product of familiarity with the mechanical, operative, and commercial conditions under which it has to be used, a familiarity which comes only from the combination of trained engineering skill with long experience.

# Manufacturing News

## The Gas Power Plant of the Indiana Steel Company, Gary, Ind.

FOR more than two years past the attention of the civilized world has been directed towards Gary, Ind., where an achievement unique in the annals of industrial history is at present in process of realization. Upon the shifting sand dunes of Northern Indiana, at a point where the Grand Calumet flows into Lake Michigan, twenty-three miles east of Chicago, there are being built, in record time, a city, a harbour and enormous steel works, the largest of their kind in the world. This is all in behalf of one corporation, the Indiana Steel Company, which has secured here a site of 9,000 acres, with a lake frontage of one and three-quarter miles, on which to erect both the mills and a residence city for its employees.

Upon a visitor entering the plant, the first and overwhelming impression is that of magnitude; the second, resulting from close inspection, is of completeness coupled with simplicity; the third and most interesting concerns the practical elimination of waste. From these factors, as a natural resultant, comes "economy," the much-sought necessity of the present industrial world. Here it has been worked out with mathematical certainty.

During a decade or two past the relative cost of producing iron and steel, as compared with the constantly increasing scales of wages paid to workmen, has been reduced largely through the substitution, first, of mechanical appliances for manual labour and then of improved machinery and methods. This change has been and is still taking place all along the line, from the stripping and removal of ore beds by steam shovels to the loading of the finished rails, plates or structural parts on cars ready for shipment. At every stage of the process where new apparatus is used, if the machinery has been wisely designed, properly installed and efficiently operated, costs have been proportionately reduced and a final cheaper — usually better — product made possible.

Of late, however, there have come about still more important requirements in steel mill practice, due both to improved metallurgical processes and to the necessity of supplementing these by methods for utilizing the inevitable waste, which, consequently, is fast disappearing as "waste" and reappearing as "by-products."

For the benefit of those who have no intimate knowledge of the manufacture of steel it may be well to state, in explanation of what follows, something of the first steps of the process. When pig-iron is to be made coke, ore and limestone are put in layers in the blast furnaces and then the fires are lighted. A powerful blast of heated air is sent through the burning mass, in order to generate the intense heat necessary to melt the ore and the limestone, or "flux," into a molten mass. In the burning of the coke under a terrific forced draught it is impossible to have consumed all of the heat energy in the coke. Despite the best engineering skill (which is here exerted to make the resultant gas as "lean" as possible) all of the carbon in the coke cannot be made to unite with the oxygen in the blast, and, together with what is released in the burning of the limestone, it is carried away to the top of the furnace. The old way, in the early days of making iron, was to let it all escape into the atmosphere; later, a portion was caught and utilized for the generation of steam; and now the entire volume of this waste is, for the first time, to be made profitable on a large scale. Smaller installations of gas engines made by Allis-Chalmers Company for the Illinois Steel Company and two of the plants of the Carnegie Steel Company, as well as for other works separate from the Steel Corporation, have shown the complete success of the new system. Except for various auxiliary purposes and as a reserve in case the blast furnaces are shut down, steam has no place in the new mills.

As above intimated, the percentage of escaping gas to the heat units directly utilized in melting the ore and flux has been gradually reduced to a certain point, thereby effecting very appreciable economy; but, when the minimum as yet known has been reached, there remains enough calorific value in the tunnel-head gases of a 500-ton blast furnace, such as the Indiana Steel Company uses, to extract about 30 per cent. for heating the stoves and still leave a tremendous volume of gas available for power, to be used in furnishing the blast, operating the steel works adjoining and minor purposes about a blast-furnace group, including steam reserves and other auxiliaries (provided it is put to work in the cylinders of internal-combustion engines), in accordance with the latest modern practice. The gas engine, in this connection, is two to three times as efficient as the steam boiler and steam engine.

It has been demonstrated, both by the installations mentioned and others made abroad, that, with the utilization of gas engines, batteries of blast furnaces can be depended upon to develop enough power for all of the purposes above mentioned, making the entire plant, except for ore, coke and limestone, literally "self-contained."

At Gary the plan calls for sixteen blast furnaces of the most approved type, eight of which are now completed or under construction. These are of standard design and need not be described in detail. The most interesting feature of the system is the link connecting them with the power station and blowing-engine houses, viz., the gas-cleaning plant, which immediately adjoins the furnaces and stoves.

When the vast volume of dust-filled gas is blown to the tops of the blast furnaces it passes from each, through four outlets, into two large pipes known as "downcomers," which lead into a reservoir, 30 feet in diameter by 40 feet high, called the "dry dust catcher." There a considerable part of the impurities settles to the bottom and the gas passes into another large pipe, which leads upward some distance to increase the quantity of dust dropped and then turns down again, emptying into a supplementary tank 14 feet in diameter by 25 feet high, one of which serves each pair of furnaces. This

structure not only provides an additional dust-catcher, but also acts as a valve, being divided into two compartments partially filled with water. By increasing the height of the water in either one the furnace on that side can be cut off as desired, and there will be no back flow of gas from the mains beyond. The two chambers of this tank discharge into a pipe 10 feet in diameter, which carries the gas and remaining impurities into the primary "wet" washers. There are three of these to each pair of furnaces, and each has capacity sufficient to take care of the gas from a single furnace, thus providing a spare washer for use while one is being cleaned or repaired. The primary washers are cylindrical in form, with cone bottom and cone top, and are about one-third full of water, a proper overflow maintaining the required level. Here the gas and dust is discharged against the surface of the water from pipes with fluted edges like a petticoat, and then escapes around these edges into openings from a larger main. At this point a small percentage of the gas is diverted to special furnaces under a battery of Rust boilers used for making steam, and about 30 per cent. is taken for heating the stoves. The remainder continues on to the secondary washers. First of this group are the vertical scrubbers, drums about 14 feet in diameter by 50 feet high. A torrent of water cascades down through it, and from near the bottom of the drum comes the stream of gas against it. Rising to the top, the gas again passes on into what are known as Thiessen washers, of which there are four to each pair of blast furnaces. In each of these it is led between the wall of a cylinder and a revolving drum armed with a series of paddle-like blades. A stream of water is spread into a film on the surface of the cylinder, and the whirling drum throws such impurities as the gas still holds out against the water film, where they are caught and held. From these final washers the gas is conveyed under slight pressure to the holders, each of which has 200,000 cubic feet capacity, from which it goes, as required, to the electric power station and blowing-engine houses. The water for the various processes described above is furnished by four large Platt turbine pumps.

Sixteen blast furnaces produce about 44,900,000 cubic feet of gas per twenty-four hours, equivalent, when used in gas engines, to 500,000 brake-horse-power. Of this quantity approximately 30 per cent. is taken for heating the stoves, 7½ per cent. is diverted to steam boiler furnaces, 5 per cent. is consumed by various auxilaries or lost in the process of cleaning, 12½ per cent. operates the gas engine-driven blowers and 45 per cent. supplies the electrical power station.

For the eight furnaces thus far erected there are two blowing-engine houses of similar construction to the power station described below. One is 600 feet long and 104 feet wide and the other is of the same width, but only 530 feet long. The difference is due to the fact that the first-named house includes a central pumping and hydraulic power plant, equipped mainly by the Snow Steam Pump Works, of Buffalo, N. Y. Besides gas engines each house contains two steam-driven Tod blowers, but when the plant is in full operation these will not be used.

Each of the sixteen blowing engines consists of a horizontal, twin-tandem gas engine of 2,500 horse-power, having cylinders 42 inches by 54-inch stroke and two direct-driven blowing tubs having a capacity to deliver 30,000 cubic feet of pure air per minute against a pressure of 18 pounds per square inch, and so designed and proportioned that they can be operated at any pressure up to 30 pounds.

These blowing tubs are of the Slick type, the patents for which are controlled in the United States by Allis-Chalmers Company. By using

this type an inlet valve area of 25 per cent. and over is easily attainable, thus insuring that the cylinder will fill completely at any speed at which the engine is able to operate it. The gas and air cylinders are located at opposite ends of the engine frame. Eight of these engines were built by the Westinghouse Machine Company and eight by Allis-Chalmers Company.

The power station, which is 966 feet long and 105 feet wide, with forty-two 23-foot bays, is located immediately adjacent to the blowing-engine houses and between the blast and open-hearth furnaces. This places it advantageously for fuel supply and insures minimum lengths of transmission lines to the various departments using electric power.

In this central station are installed seventeen horizontal, twin-tandem, double-acting gas engines, turning at a speed of 81 1/3 revolutions per minute, fifteen of which are designed for coupling to alternating-current generators and two to be connected to direct-current generators. The former are 25-cycle, three-phase, 6,600-volt machines, and the latter deliver current at a pressure of 250 volts. The engines have a rating of 4,000 horse-power and the generators 2,000 KW., but they are capable of carrying continuously 30 per cent. overload. The seventeen units were built complete by Allis-Chalmers Company.

These are the largest engines in the world to operate on blast-furnace gas, being practically duplicates of the units built for the Illinois Steel Company, as above mentioned, operated in parallel. The successful working of that plant insured the success of the Gary installation.

The distinctive features of the engines, or those which appeal most strongly to engineers who have seen them in service, are the extreme simplicity of design, the solidity of construction and the quiet operation. Maximum overloads are handled as easily and with the same freedom from vibration that characterizes their operation under normal conditions; the engines turn their centres as quietly as a slow-running Corliss machine and with apparent indifference to the rapid changes in load which, in steel mill service, they are called upon to sustain.

While the engines are, as a whole, exceptionally rigid and heavy, the weight is concentrated in the frame cylinders and tie pieces in the direct line of stresses to which an engine of this type is subjected. In the frame is illustrated the principal difference between European and American design. This frame is designed for a side crank in place of the double-throw crank which represents the standard practice abroad. The stresses transmitted to the frame in a side-crank engine are very great; but, even in the largest-sized gas engines, they are no greater than the builders have for many years successfully provided for in steam-engine practice.

The jaw, which is subjected to peculiarly severe stress, is made in a form to insure maximum strength of the casting, and is further strengthened by two steel tie bolts carried above the shaft, which are made of sufficient size to carry their proportion of the load without appreciable elongation. This construction eliminates entirely any bending stresses in the frame at this point.

The engine frames weigh approximately 90 tons each, and one-half of each frame is buried in the foundation, in order to raise the floor line to a point which will make the rods on the valve gear readily accessible.

The floor space occupied by one engine is 70 feet by 44 feet, and the weight approximates 1,700,000 pounds. The cylinders are 44 inches by 54 inches stroke, the crank-pins are 20 inches in diameter, the shaft is 30 inches in diameter in the bearing, and the flywheel is 23 feet in diameter, weighing 20,000 pounds. The pistons and rods are water-cooled, water being introduced at the cen-

tre and flowing forward to a discharge in the frame for the front piston and backward to a discharge in the tail guide for the rear piston, each piston having its separate supply. For dismantling or for cleansing, the rod is made in two parts joined at the central slide, the rear half going out at the back of the engine and the other half going out through the frame, which is made open at the top for convenience.

The valve gear is located between the engines, concentrating on a twin-tandem in such a way as to make it very convenient for the operating engineer.

This gear is of the builder's standard stratification type, and the engine operates with constant compression, thus tending to insure smooth running under the highly variable loads to which it is subjected.

The igniters are electrically controlled and so arranged that the time of ignition may be regulated by a single hand wheel. Direct current at 80 volts is used in the ignition system. Duplicate independent igniters are provided at each end of the cylinder, to insure prompt firing of low heat-value gases and also to avoid the danger of shutdown due to short-circuit. The entire ignition system, from the motor-generator set which furnishes the current to the electrically-operated igniters, is the most solidly-built apparatus ever furnished for this purpose.

The air-starting device consists of a small poppet inlet air valve at each end of each cylinder operated by the layshaft. Air is admitted to each cylinder, in turn, at what would be the working stroke. As the high compression carried prevents the engine from stopping on the dead centre, this arangement insures the prompt starting of even a tandem engine without the use of a barring gear. These engines being twin-tandem, will, of course, start from any position.

All wearing surfaces, including the main bearings, slides, crank and crosshead pins, are arranged for a continuous oiling system, and the cylinders are lubricated by carefully timed admission of the cylinder oil, sight-feed oil pumps being used.

The exhaust from the gas engines is conveyed to a tunnel 12 feet by 9 feet, located immediately outside the building and beneath the ground level. This runs the length of the building, and is provided at each end with a stack 9 feet in diameter by 92 feet high. The same method of muffling the exhaust is provided for the blowing engine houses.

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## Mining Development in Argentina

THE Famatina Development Corporation, which is interested in the development of copper mines near Chilecite, Argentine, is installing a hydro-electric plant, the generating equipment for which consists of two 200-KW., 240-volt revolving-field generators with direct-connected exciters, together with a suitable switchboard and transformers for stepping the voltage up to 13,200 volts. The generators are belt-connected to a line shaft driven by two Pelton water-wheels 4 feet in diameter, capable of developing 630 horse-power at 300 revolutions per minute. The head is 230 feet, the pipe line being 6,661 feet in length.

In addition to the generating station there are also two sub-stations, one located at the smelter, a short distance from the generating station, and the other at the mines. The power in the smelter is taken direct at the generator voltage, while that in the mine is stepped down from 13,200 to 240 volts. In addition to the apparatus mentioned above, the General Electric Company also supplied several induction motors of various sizes for use both at the mines and at the smelter.

This installation is comparatively small, but is interesting from the fact that it includes a 20-mile transmission line to the mines.

### An Interesting Transformer Plant

AN initial shipment of water-cooled power transformers, forming part of an ultimate equipment of thirty-six transformers, aggregating 10,530 KW., for the United States Reclamation Service in connection with the Salt River, Arizona, irrigation project, has recently been made by the Wagner Electric Manufacturing Company. The specifications for these transformers were issued last summer, and the contract was awarded to the Wagner Company under severe requirements as to insulation, operating characteristics, etc., and also under rigid stipulations as to prompt delivery. The recent shipment comprises six 350-KW., 25-cycle, 2,300-26,000-volt step-up transformers and nine 235-KW., 25-cycle, 23,100-1,100-volt step-down transformers, the design of the transformers required dealing with certain special conditions at the places of installation, among which were the limited space for handling the transformers in the power house and the high temperature of the cooling water due to the hot climate of the desert region. The water is circulated through the cooling coil of each transformer by a Wagner three-phase, motor-driven triplex pump.

### New Post Office at Ampere, N. J.

IN order to facilitate handling the increasing volume of mail at the Ampere, N. J., post office, the Crocker-Wheeler Company, manufacturers of electrical machinery, have built a brick and cement post office building on their grounds. The architecture is of a modern classical style which might be termed "federal." Upon the pediment above the main entrance is an eagle and United States shield in high relief. The interior of the building is finished in quartered oak, and the floor is of mosaic tile. Upon the walls hang a fac-simile of the Declaration of Independence, with the coats-of-arms of the various States, a Constitution of the United States and an autograph letter and portrait of A. M. Ampere (1775-1836), after whom Ampere is named, and whose name is also used throughout the world to designate the unit of electric current. The new post office will still further beautify the grounds of the Crocker-Wheeler Company.

### Pressed Radiators

A NEW way of making radiators for steam and hot-water heating is announced in some advertising literature recently issued by the Pressed Radiator Company, of Pittsburg. The new radiator, instead of being made up of a set of iron castings, as hitherto, consists of a light but rigid sheet-metal structure fashioned and assembled by special machinery. Each section is made up of a pair of the metal sheets, dished or "pressed" to the required shape and joined by an impervious seam capable of withstanding the steam or hot-water pressure without leaking in service. The completed section is then heavily galvanized inside and out. These pressed radiators are smaller and lighter than cast-iron radiators and, on account of their lightness, they are cheaper to install. Another advantage is that the comparatively thin walls of the radiator permit it to heat up and cool off very quickly.

### Goldschmidt Thermit Company

A NEW machine shop and foundry is under construction for the Goldschmidt Thermit Company, 90 West street, New York City. The building occupies a site, 34 x 90 feet in size, just back of their present factory in Jersey City, and is to be fitted up for the purpose of handling to better advantage the extensive repair work which is now being carried on at these works. Traveling cranes will be provided, and no expense will be spared to make the building the most complete thermit repair shop in the country. Special attention will be

paid to the rapid execution of the repairs to electric motor cases, truck frames, cast-steel gear wheels, crankshafts and, in fact, any wrought-iron or steel sections not exceeding 2,000 pounds in weight.

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### An Improved Face Grinding Machine

THE Emmert Manufacturing Company, of Waynesboro, Pa., has placed on the market an improved face grinding machine, designed for grinding lathe and planer tools and for squaring up the ends of work and similar miscellaneous small jobs of grinding in the tool-room and shop.

One of the novel features of this machine is the provision for use of a diamond for truing up both the face and the periphery of the wheel.

A straight edge or surface on tools and a straight face on the edges of work is much easier and more accurately obtained by using the face of the wheel, provided that face be straight and the wheel be of suitable character. Such a face cannot be obtained with an emery wheel dresser, nor can the diameter of the wheel be kept true with a dresser.

Recognizing these facts, the manufacturers of this tool have provided a work table located in front of an extension by the edge of the wheel, so that both the face and edge of the wheel can be used for grinding. This table is located in a guide carried by a transversely swinging arm, and in the end of the arm a longitudinally adjustable diamond holder is located; normally the table can be either clamped, to prevent any transverse rocking movement, or adjusted to allow a certain amount of such movement, as is often an advantage in grinding wide work; when the surface of a wheel becomes dull or untrue an adjustable stop below the table is moved out of its path and the table swung backward away from the wheel, at the same time swinging the diamond across the face of the wheel so as to give the latter a good cutting and a straight surface.

The table is also slidable longitudinally of the machine in the guide, and is provided with a threaded hole to receive the diamond holder, which may be transferred to this hole and the edge of the wheel trued off by sliding the table in its guide. The table guide is pivoted in the diamond carrying arm, and can be set by means of graduations and clamped at any angle with the face of the wheel up to 45 degrees.

Upon the table is also provided an adjustable squaring device or protractor, which may be set from 90 degrees to 45 degrees with the surface of the wheel.

The diamond holder may be quickly transferred from one end of the machine to the other, and with a little care the diamond will last indefinitely.

The wheel spindle of this machine is hardened and runs in adjustable bronze boxes.

The wheels used are 12 inches in diameter by 1½ inches in thickness and are recessed.

A water tank of ample capacity is provided for cooling work, located convenient to the operator.

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### An Important Special Number

THE round-the-world cruise of the American fleet has attracted attention, not only at home, but also among the great powers of Europe. When the Russian fleet started on its journey from Libau to meet its fate at Tshushima, the mere fact of its long voyage was considered one of the great hazards of war. The voluntary undertaking of a far longer and more difficult journey by the American fleet has attracted interested attention to the subject of marine and naval engineering, and this renders of especial interest the forthcoming issue of CASSIER'S MAGAZINE, devoted as it is to the subject of the latest developments in the design and construction of vessels, and of their propelling machinery. This notable number forms an effective addition to the already famous series of CASSIER'S specials.

# THE LATEST CATALOGUES

**Bridges**

THE SCHERZER ROLLING LIFT BRIDGE COMPANY, Chicago.—Handsomely illustrated treatise upon the development of the Scherzer rolling bridge, with a review of the history of drawbridges and a discussion of the methods of crossing a river while maintaining an open channel for navigation. A large number of photographs of Scherzer bridges are reproduced, showing the wide adaptability of the system, while the partial list given shows the extent to which the method has been introduced in all parts of the world. This is one of the modern trade publications which may be considered as valuable treatises upon a special department of engineering work, and should be examined by civil, railroad and municipal engineers before making any decision as to the problems to which it refers.

**Gas Engines**

THE BRUCE-MERIAM-ABBOTT COMPANY, Cleveland, Ohio.—Section I, Catalogue A, devoted to vertical gas engines for electric lighting, pumping and general power purposes. Two distinct types of multiple-cylinder vertical engines are illustrated, one for use with natural gas and one adapted for producer gas, each designed to secure the best efficiency for the fuel with which it is operated. The engines are of the four-stroke cycle, with throttling governor, the regulation being effected without altering the ratio of gas and air. A table of comparative fuel costs of various powers is given and the high efficiency of the suction-producer system shown.

WEBER GAS ENGINE COMPANY, Kansas City, Mo.—Catalogue No. 22, describing the Weber gas engine, both of the double and triple-cylinder types, with illustrations showing the general arrangement, as well as details of construction. The flexible leather-link coupling for use in connecting the gas engine to a dynamo shaft is shown, and the losses in steam power plants, as compared with gas power, are discussed. Especial attention is given to the Weber suction gas producer, and the high economy and simplicity of the combination of gas engine and suction producer appears in the tabulated summary of the cost of various methods of generating power.

**Electric Lighting**

NERNST LAMP COMPANY, Pittsburg, Pa.—Bulletin "A," containing useful information about the Westinghouse Nernst lamp, with illustrations of various ornamental fixtures, diagram showing the distribution of illumination and comparative table of the operating costs of various electric-lighting systems based on equal illumination. The high efficiency of the Nernst system is demonstrated, and the advantages of the improved glower are fully set forth.

**Brushes**

LE VALLEY VITÆ CARBON BRUSH COMPANY, New York.—Catalogue No. 5, listing a variety of carbon brushes for dynamos and electric motors. The makers specifying Le Valley brushes for their machines are noted, and sample sketches to guide in ordering special forms are given. A price list of stock sizes is appended, and a number of testimonials from users are reproduced.

**Indicators**

THE AMERICAN STEAM GAUGE & VALVE MANUFACTURING COMPANY, Boston, Mass.—Illustrated 1908 catalogue of the improved Thompson indicator, giving information concerning the various forms of this well-known instrument for steam engines, gas engines, ammonia compressors and similar machines. The improved detent motion is illustrated, also the electrical attachment for taking simul-

taneous diagrams with several instruments, and a description is given of the apparatus used by the manufacturers for testing and calibrating indicator springs. Examples of indicator diagrams are included, together with testimonials from professional engineers.

### Cable Joints

Dossert & Co., Inc., New York.—Pamphlet describing the Dossert solderless connector for making cable joints or connecting solid wires for electrical purposes. A section of the joint is given, together with instructions for use, the connection being made in three types, according to the tension on the conductor. By the use of these appliances any ordinary workman can make electrical splices, tap-offs or terminal connections without using solder, the carrying capacity of the joint exceeding that of the cable with which it is used.

### Thermometers

The Bristol Company, Waterbury, Conn.—Bulletin No. 93, describing the Bristol recording thermometer as adapted for working ranges from 40 to 800 degrees Fahr. These thermometers depend for their action upon the pressure due to the expansion of a gas contained in a bulb which is connected with a Bristol recording pressure gauge by a small, flexible copper tube. The bulbs are made for use in various situations, either open or closed, under atmospheric or higher pressures, and the instruments are adapted for a great variety of industrial operations in which a reliable, continuous record of temperature changes is required.

### Blowers

P. H. & F. M. Roots Company Connersville, Ind.—Catalogue No. 32 of the Roots positive pressure blower, as adapted for foundry cupolas and for higher pressures. The various methods of driving the positive pressure blowers are shown, and the applicability of the machine as a pump and as a gas exhauster is indicated. An interesting illustration in the catalogue is that of the special planer devised for finishing the impellers used in these machines.

### Controllers

General Electric Co., Schenectady, N. Y.—Bulletin No. 4,578, describing the essentials of the various standard railway motor controllers manufactured by the company, including the magnetic blowout, cut-out switches and general interchangeability of parts. The more important types are illustrated, and tabular data and dimension diagrams are appended.

### Piles

Lock-Joint Pipe Company, New York.—Pamphlet illustrating the use of lock-joint pipe for the protection of timber piles from the attacks of marine insects and wood borers. The piles are enclosed in sections of cement pipe, the intervening space being filled with sand and the tops sealed with cement. Illustrations of the application of the pipe are given and elevation and sections showing the locking system.

### Heating

Consolidated Car Heating Company, Albany, N. Y.—Catalogue No. 8, Parts I. and II., devoted to the subject of electric heaters for warming railway cars, illustrating a great variety of heaters, with wiring diagrams, switches, couplers and fittings. The McElroy spiral coil construction is described, enabling a large radiating surface to be secured, avoiding the necessity for excessive temperatures by providing ample surface for the dissipation of the heat. Useful information relating to electric heating is given and information to aid in the selection of an equipment for any required situation.

## The Development of the Theatre Dimmer

FEW people recall, nowadays, that one of the early objections to the incandescent lamp was that it could not be dimmed and brightened like gas light. Reference to this forgotten fact is made in a pamphlet entitled "Stage Lighting," recently issued by the Cutler-Hammer Manufacturing Company, of Milwaukee, which for the past fifteen years has been manufacturing theatre dimmers.

"In the early days of the incandescent lamp (says the pamphlet in question) how to diminish and increase the brilliancy of the lights for stage purposes was something of a problem. The old-time gas man could raise and lower his lights by degrees, but the early stage electrician was obliged to secure sunset and similar effects in four or five jumps—cutting one bank of lights after another completely out of circuit, and leaving such lights as remained in circuit at full candle-power. Then came the theatre dimmer, and the gas man disappeared, for with the advent of the dimmer the stage electrician was at last able to secure the gradual dimming of the lights so essential to the production of realistic effects."

That stage-lighting practice itself has changed is made evident by the fact that early types of dimmers were designed to handle a large number of lights on a single circuit. "Ten years ago it was the general practice in theatre lighting to place as many as 150 lamps on the same circuit. The demand nowadays, on the contrary, is for dimmer plates of smaller individual capacity, the idea being to secure better control of the lights by increasing the number of circuits and placing fewer lamps on each circuit."

The improvements made in dimmers in the last ten years are strikingly illustrated by contrasting the cut of an old-time dimmer with the many views of modern installations shown in the pamphlet. The long throw of the operating lever has been shortened to a throw of a few inches by the substitution of a rack-and-pinion drive for the old-time construction, in which the contact shoes were mounted directly on the operating lever. The bulky, oblong dimmer plate of the past has been replaced by a compact circular plate measuring only a few inches in diameter and thickness, each plate being capable of dimming as many as fifty 16-candle-power lamps. The method of mounting the dimmer plates in the supporting frame has also been so improved that the removal of only three screws enables one to lift any plate from a bank of dimmers without disturbing any of the other plates.

The difference between non-interlocking and interlocking dimmers is fully described and illustrated in the Cutler-Hammer pamphlet, and many trade terms are explained, such, for instance, as the difference between "back of board mounting" and "rear of board mounting," the former indicating that the dimmer plates are mounted directly on the back of the panel, as shown in the accompanying illustration, while the latter signifies a type of construction in which the panel supports the weight of the operating levers only, the dimmer plates being designed for mounting on an adjacent wall behind the switchboard.

"Stage Lighting" will be read with interest by all whose work brings them in contact with theatrical installations. The subject of theatre dimmers has never been more fully treated than in this 48-page booklet, with its nearly two score illustrations and diagrams. Pictures of the dimmers used in many of the leading theatres of the country are shown, and the construction and operation of this important piece of theatrical apparatus are very fully described and illustrated. Copies of "Stage Lighting" can be obtained, free of charge, by addressing the Cutler-Hammer Manufacturing Company, Milwaukee, Wis.